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FINAL REPORT

EVALUATION AND DEMONSTRATION OF DEADS COMPOSTING AS AN OPTION FOR DEAD ANIMAL MANAGEMENT IN SASKATCHEWAN

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Evaluation and Demonstration of Deads Composting as an Option for Dead Animal Management in Saskatchewan

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Agriculture and Bioresource Engineering
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Evaluation and Demonstration of Deads Composting as an Option for Dead Animal Management in Saskatchewan

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ABSTRACT

Pork producers in Saskatchewan are continuously looking for new developments that are both economic and environmentally sustainable. Composting is a potential option for dead animal management that may meet both requirements. The purpose of this investigation is to determine whether or not composting is a viable option for dead animal disposal for hog producers in Saskatchewan. The test compost pile constructed in October 1999 containing the mortalities (deads pile) consists of a straw/manure mix that is provided by animal shelters of the operation with deads added to this mix in increments of 150 kg. An additional compost pile composed of straw/manure mix was constructed at the same time for the purpose of examining the potential for volume reduction. Temperature, oxygen, volume reduction and moisture conditions were monitored to track microbial activity and to evaluate the overall progress and efficiency of the composting mortalities. Early observations of the deads compost pile during pile aeration revealed that the carcasses were broken down successfully. This was verified when the deads compost pile was screened revealing a minimal amount of uncomposted materials. Composting mortalities produced a useful product that could be utilized as a soil amendment with sufficient nutrient values and a reduced volume that will help to decrease transportation costs.

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TECHNICAL REPORT

1.0 Background

The expansion of the hog industry in Saskatchewan has created the need for new advancements to develop an economically and environmentally sustainable industry. Dead animal management is just one area of the livestock industry that producers need to be mindful of. Faced with increasing costs, concerns about environmental pollution and disease transmission, livestock producers and environmental officials are seeking more sustainable options for on-farm disposal of dead stock (Glanville 1994).

1.1 Dead Animal Management in Saskatchewan

Traditional methods used for dead animal disposal in Saskatchewan include rendering, incineration and burying. Rendering is a method in which dead stock is picked up at the production site and transported to a rendering facility where carcasses are recycled into useful byproducts. Due to the limited number of rendering facilities in Western Canada and the cost potential for transportation, the volume of carcasses produced determines if rendering is the most economic disposal option. Biosecurity is also a concern regarding this type of facility as the transport trucks traveling between many locations in a trip, thus increasing the risk of herd contamination.

Burying is a common method of disposal that has been long accepted in Saskatchewan. Regulations state that animal remains may be buried, however the bottom of the pit must be at least 1 m above any water bearing formation and the carcasses must be covered with a minimum 0.6 m of soil. The burial pit must be located in a medium to fine textured soil, away from areas subject to flooding and at least 90 m away from a watercourse, a body of water or a water well (SAF 2000). Burial as a method of disposal in Saskatchewan can prove to be difficult for producers during winter months when the ground is frozen. Larger hog operations may have refrigeration facilities on site to store deads where a large enough number may accumulate to make transport economical. Refrigeration is usually associated with eventual disposal to a rendering plant, but may also be used for storage during winter months when burial is not possible.

Incineration of mortalities is a method that is used in Saskatchewan, but is carefully monitored to ensure that proper procedures are followed. In this province, Saskatchewan Environment and Resource Management requires producers to have a license enabling them to install and operate an incinerator. Economics must also be considered when choosing this type of disposal method since incineration requires a great deal of energy to fully complete the process.

Composting is a natural process where microorganisms decompose organic material in a primarily aerobic environment (Rynk 1992 and Haug 1993). Microorganisms consume

oxygen for fuel as they feed on organic matter resulting in a metabolic release of heat, carbon dioxide (CO_2) and water vapor into the air. Carbon dioxide and water can contribute up to half the weight of the raw materials therefore the loss of these two components can cause significant volume and mass reduction (Rynk et al. 1992). At present, composting in the food processing and agriculture industries has great potential to be an environmentally sound method to manage waste produced while generating a useful soil amendment as the final end product. Composting as a method of dead animal disposal in Saskatchewan has been primarily used for poultry and smaller animals. Preliminary research and field studies suggest that mortalities from hog operations may also be successfully composted.

1.2 Composting Swine Mortalities

Composting has proven to be an environmentally sustainable method to dispose of swine carcasses and has been accepted in many areas of the world (Fulhange and Ellis 1997). Due to their inconsistent nature, composting swine carcasses is unlike typical composting where materials are thoroughly mixed to ensure proper distribution. The pile in this case consists of a large bulk of material, the carcass, which has a low C/N ratio, low porosity and high moisture content encompassed by the carbon amendment, a material which has a high C/N ratio, good porosity and moderate moisture. Initial decomposition is anaerobic in and around the carcass, however as the decomposition process continues gases and liquids are released, they diffuse away from the area and are trapped in the aerobic zone of the surrounding material. Microorganisms within this zone ingest and degrade the gases into CO_2 and water vapor (Keener et al. 1999). The compost pile is not turned until decomposition of the carcasses has been completed. For swine, this period is approximately 3 months after the last pig has been placed on the pile. The pile is then turned, incorporating oxygen into the mix to further fuel microbial activity and an additional 3 months is required to allow the compost to cure (Henry 1995, Keener et al. 1997 and Pittaway 1998) A study conducted in South Carolina has shown within a 5 month time period, all that remained of a 295 kg, 10 year old boar was a dark humus like material and some large bones and teeth (Henry 1995).

1.3 Composting Swine Manure

Manure is a valuable resource of nutrients. Livestock are inefficient at extracting nutrients from their feed. Typically 75 – 90% of the major nutrients found in feedstock are detected in the manure. Composted manure is a preferred soil amendment over the application of raw manure by some since the highly soluble nutrients in the raw manure have the potential to quickly leach away while humus-like composted manure slowly releases nutrients into the soil and enhances the microbiotic environment (McGill University 1992). Swine manure independently has been classified as being nitrogen-rich with a high moisture content making it slightly more difficult to compost relative to other livestock manures. Odor is also a concern with this form of waste. Straw incorporated into the swine manure will improve its compostability by lowering the moisture content, increasing the carbon content and by providing some odor control (Rynk 1992). Research using a straw/manure mixture has shown composting can be accomplished but may

require a longer period of time when compared with using sawdust as a carbon source (Pittaway 1998, Morris et al. 1998).

1.4 Factors Affecting Composting

1.4.1 Temperature and Oxygen

Temperature and oxygen content within the compost pile are key indicators of the progress of the composting process since the release of heat and the consumption of oxygen is directly related to microbial activity. All organisms have a temperature and oxygen range in which they can function optimally thus initiating and sustaining biochemical reactions. Monitoring oxygen and temperature values throughout the composting process is essential to ensure a successful end result.

Composting process temperatures generally follow a pattern that begins with the active composting stage where a rapid increase in temperature to around 50 - 60°C occurs as readily available compounds are ingested. Thermophillic bacteria that thrive in this temperature range are found to be the most efficient at decomposing material in a composting environment (Henry 1995). The temperature remains in this zone for several weeks. Oxygen supplies may become depleted during the active composting period thus slowing down activity resulting in a decrease in temperature. A minimum of at least 5% oxygen is required to maintain activity. Aeration, accomplished by pile turning or by forced aeration, is necessary to replenish supplies to recommence activity as well as remove water vapor and other gases that may be trapped within the pile. If conditions are especially favorable for microbial degradation, activity is intense and the temperature may rise well above 60°C. For every 10°C rise in temperature, the rate of biochemical activity is found to double. However, temperatures to the high or low extremes may limit the process kinetics (Haug 1993). Temperatures in the range of 75 - 85°C are likely depressing activity since microorganisms die or become dormant in extreme temperatures and aeration is required to cool the pile (Rynk 1992 and Haug 1993).

As decaying activity slows, the compost enters the curing stage and a drop in temperature to approximately 30 - 40°C is noticed, followed by a gradual decrease to ambient air temperature as the process stabilizes. The rate of oxygen consumption slows therefore aeration is not essential during the curing stage. The composting process does not have a definite endpoint, microorganisms will continue to biodegrade organic compounds until all remaining nutrients are consumed and all carbon is converted to CO_2. Cured compost becomes stable having a dark brown to black color, an earthy odor and a temperature which eventually equals that of ambient conditions. Once the compost has cured for the required amount of time, it may be incorporated into the producers manure management plan or marketed as a soil amendment.

1.4.2 Nutrients

Nutrients, mainly carbon (C), nitrogen (N), phosphorus (P) and potassium (K) are required by microorganisms driving the composting process to support biological action. As well, the value of the finished compost is largely predicted by nutrient concentrations

since N, P and K are the chief nutrients used by plants. Nitrogen and C are especially important since C provides energy and growth for microorganisms while N is necessary for protein development and cellular reproduction. A ratio of carbon to nitrogen (C:N) has been adopted by the composting industry as a measure of a suitable nitrogen balance, and as a method to ensure that other required nutrients are present in appropriate amounts. For the purpose of composting, raw materials blended to achieve a C:N ratio between 25 and 30 (25:1 and 30:1) has been reported to be ideal, although ratios above 50 have been reported to be effective but require a longer composting period for complete carbon utilization (Haug 1993 and Rynk 1992). A C:N ratio below 20 indicates that the available carbon has been utilized and converted to CO_2, and the remaining unstable nitrogen may be lost as ammonia (NH_3) or nitrous oxide (N_2O) which may result in unpleasant odors. Odor can therefore be controlled in the composting process if there is a proper C:N ratio which will provide enough carbon to ensure that the majority of nitrogen will be stabilized.

A typical nutrient profile for swine manure in Saskatchewan is found in Table 1. Cereal grain straw is found to contain a C:N ratio ranging from 128-150 (Haug 1993). The resulting mixture of these two raw materials will provide a sufficient mixture for mortality composting.

Table 1. Average nutrient values for swine manure in Saskatchewan.

Nutrient	Type of Manure	
	Liquid Swine (kg/1000 L)	Solid Swine (kg/tonne)
Nitrogen (N)	3.0	8.4
Phosphorus (P)	0.9	4.6
Potassium (K)	1.0	10.8
Sulphur (S)	0.4	3.2

(SAF 1999)

1.4.3 Moisture Content

Moisture levels are important in a composting operation. Water acts as a media to support the metabolic activity of the microorganisms. A moisture content of 40 – 70% by weight is recommended for optimum activity in most materials (Shuler 1980, Rynk 1992 and Haug 1993). Below a level of 40% moisture content degradation continues to slow and at a moisture content of 15%, activity ceases entirely. At levels above 70%, water begins to inhibit the flow of oxygen by lowering the free air pore space within the pile affecting the balance of elements needed by microorganisms to thrive. Moisture values naturally present in swine carcasses should be sufficient for composting without an additional moisture source since the tissue of swine is found to have a moisture content greater than 70% (Pittaway 1998).

1.5 Composting Swine Mortalities in Saskatchewan

Mortalities are unavoidable on any type of livestock operation as a result of disease, accidents or competition. Composting swine mortalities has great potential to be a method of dead animal management on hog operations in Saskatchewan. Manure is

generally readily available and animal deaths are inevitable. Table 2 shows volume of manure produced and number of deaths expected on a typical hog operation in Saskatchewan. Composting can be a solution for dead animal management which is economical, environmentally sustainable and provides a useful end product.

Table 2. Swine manure production and expected animal losses in Saskatchewan.

Animal Type	Daily Manure Production for Storage		Average Death Loss (% per cycle)	Cycles per Year
	Solid (kg/animal/day)	Liquid (l /animal /day)		
Boars and gestating sows (150 kg av)	21.1	15.9	3	1
Nursing sows (150 kg av)	29.0	21.8	3	1
Gilts (125 kg)	16.9	12.7	1	1
Feeder pigs (100 kg)	11.3	8.5	1	3
Weanling pigs (16 kg)	2.1	1.6	1.5	6

(SAF 2000)

2.0 Project Objectives

The objective of this project was to determine the viability of composting as a method of dead animal disposal for hog producers in Saskatchewan. This management option was demonstrated and analyzed on a commercial hog operation over a two year period. Results from this study will help to establish guidelines and protocols for producers to help implement this practice of disposal in Saskatchewan.

3.0 Project Outline

3.1 Materials and Methods

3.1.1 Compost Pile Construction

The initial deads compost pile was constructed October 1999 at Marval Acres Stock Farms, Hepburn, Saskatchewan. This particular operation is a 350 farrow to finish where finishing takes place in a series of 14 covered shelters which use straw as bedding for the animals (Photo 1). The pile was constructed in a field near the operation where enough room was available for pile turning and for the producer's machinery to easily access the piles. The estimated area used for composting is approximately 1000 m^2. Deads compost pile construction was modeled after the method described by Keener et al. (1998). The initial deads compost pile (labeled Deads I) was built by constructing a manure/straw mix base approximately 0.6 m thick with an area of 4m x 6m to accommodate the producer's available equipment. A group of deads totaling approximately 145 kg, was placed on the base side by side and then covered by a layer of straw/manure mix 0.6 m thick. A second group of deads, totaling 128 kg was laid beside the first group and again covered by a layer of manure/straw (Photos 2 & 3). Samples of the covering and base were collected for a baseline nutrient analysis. This method of pile construction continued until early February 2000 when a new pile was started. The initial deads composting pile incorporated a total of 2845 kg of swine mortalities. Additional deads piles were constructed as the previously constructed pile reach a limit of approximately 2000 – 2500

kg of carcasses using the method consistent with that used for Deads I construction. Over the period of nearly a year between October 1999 and November 2000, six deads compost piles were constructed at this particular site
(Photo 4).

A pile consisting of a straw/manure mix only was constructed at the same time as Deads I (October 1999) as a control and to investigate the volume reduction potential of composting swine manure in Saskatchewan conditions. The straw manure pile was monitored in the same manner as the deads compost piles. The manure/straw pile continued to compost until August 2000, when it was concluded that this pile was finished and ready to be land applied.

3.1.2 Compost Pile Monitoring

Oxygen, temperature, volume, bulk density and moisture content were monitored throughout the study on all piles to track the composting progress. Temperature and oxygen readings were taken once a week using Demista Instrument's Oxygen-Temperature Monitor (Model OT-21). This device consists of a probe 1.5 m long that penetrates the compost pile to measure both temperature (^{o}C) and oxygen (%) (Photo 5). Temperature and oxygen measurements were taken in various positions in the piles to track the overall progress of microbial activity thus indicating when the piles required aerating. Deads pile aeration was accomplished by constructing a base of manure/straw 0.6 m thick and turning the pile onto this base using a front-end loader provided by the producer (Photo 6). The pile was recovered with an additional 0.6 m of the manure/straw mix from the shelters. The base and cover were used to provide insulation for the composting carcasses as breakdown is favored by higher temperatures. The control pile was simply re-piled by way of a front-end loader.

Volume reduction data was manually taken once a month using a standard 30 m measuring tape to obtain all piles' approximate dimensions. To further investigate volume reduction as well mass reduction, bulk density data was collected using the method described by Rynk (1992). Moisture data was obtained by collecting samples in airtight plastic bags once a month at various positions from each pile and oven drying them at a temperature of 105^{o}C to obtain the overall average moisture content for each individual pile (Photos 7 & 8).

3.1.3 Deads Compost Screening

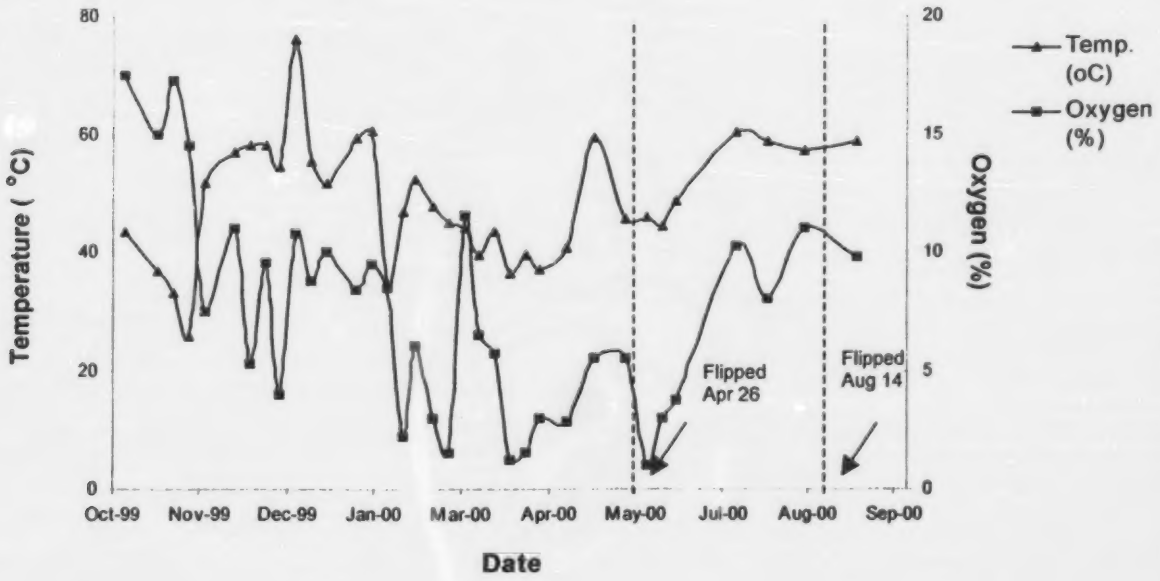
Deads I was screened in September 2000 to evaluate the amount of objectionable material that remained in the pile, i.e. any large bones or sharp fragments that may pose a threat to machinery if the compost was to be land applied. A tandem truckload approximately 11.5 m ^{3} of Deads I was loaded at the site and transported to a commercial screening operation (Photos 9 & 10). The truck was weighed before and after the compost was loaded to determine the mass of compost that was screened. As screening took place, any recognizable remains were separated out for general observation and to determine the mass of remaining material (Photos 11 & 12). The moisture content of the remains and as well of the screened compost was determined by oven-drying for 24-hrs at 105^{o}C.

The dry mass of the remaining material was compared to the dry mass of the total screened compost to evaluate the overall effectiveness of composting swine mortalities. All final samples of the screened compost, as well as samples of the final manure/straw compost were collected and taken to Enviro-Test Laboratories, Saskatoon, Saskatchewan for nutrient analysis.

4.0 Results and Discussion

4.1 Temperature and Oxygen Monitoring

Because of the cool temperatures associated with the season in which Deads I was constructed, the active composting stage took place over a period of 6 months. According to the weekly oxygen and temperature readings, the rate of active composting began to speed up slightly during warmer ambient temperatures. Temperature and oxygen readings from October 1999 through September 2000 for Deads I are shown in Figure 1. The first month of readings demonstrates the initial "bloating" stage where decomposition is accomplished by microbes found within the carcasses. As the organic material becomes more readily available to the microbes in the manure/straw medium, the temperature increases and the oxygen consumption begins. This pattern can be seen as deads were added to the pile in approximately 10 – 14 day increments. Once Deads I pile was completed the temperature and oxygen began to follow a continuous pattern: temperature values decreased as the oxygen supplies were gradually depleted. Deads I was determined to be ready for aeration when the oxygen content approached the minimum of 5% and the temperature began to decrease below 40°C.



Figur 1. Deads I compost pile temperature and oxygen measurements.

Deads I was flipped for the first time Ap[illegible]6, 2000. Observations taken during pile aeration showed that the decomposition of the swine mortalities was progressing at a satisfactory rate. Evidence of remains included bone fragments, which were found to be no larger than a human foot, and a soft pulpy substance that could not be recognized as a specific portion of a carcass (Photos 13 & 14). Temperature and oxygen values rapidly recovered soon after the first aeration. Deads I continued to be monitored, weekly for temperature and oxygen values and monthly for volume reduction, moisture content and bulk density values. Temperature and oxygen measurements indicated that this pile required aerating approximately three months after the first aeration, and the pile was flipped once again on August 14, 2000. The second pile aeration involved simply re-stacking the pile with the loader. The compost pile was a dark brownish-black color emitting no offensive odors and visual observation showed no evidence of remains (Photo 15). Deads I continued to be monitored and until it was taken to be screened September 12, 2000.

Temperature and oxygen readings for the straw/manure pile are seen in Figure 2. The initial activity in this pile commenced much more quickly than Deads I. This behavior is expected because of the more readily available organic matter in the straw/manure compared to swine carcasses. This pile was flipped for the first time on December 15, 1999 when temperature levels began to drop. Microbial activity was stimulated resulting in an increase in temperature. This pattern continued and the pile was flipped three more times during the composting period. A final sample of the compost was taken June 24, 2000 to compare the nutrients in the compost to the original material. Observations by the primary researcher concluded that this pile could be applied when land was available and when the producer was ready.

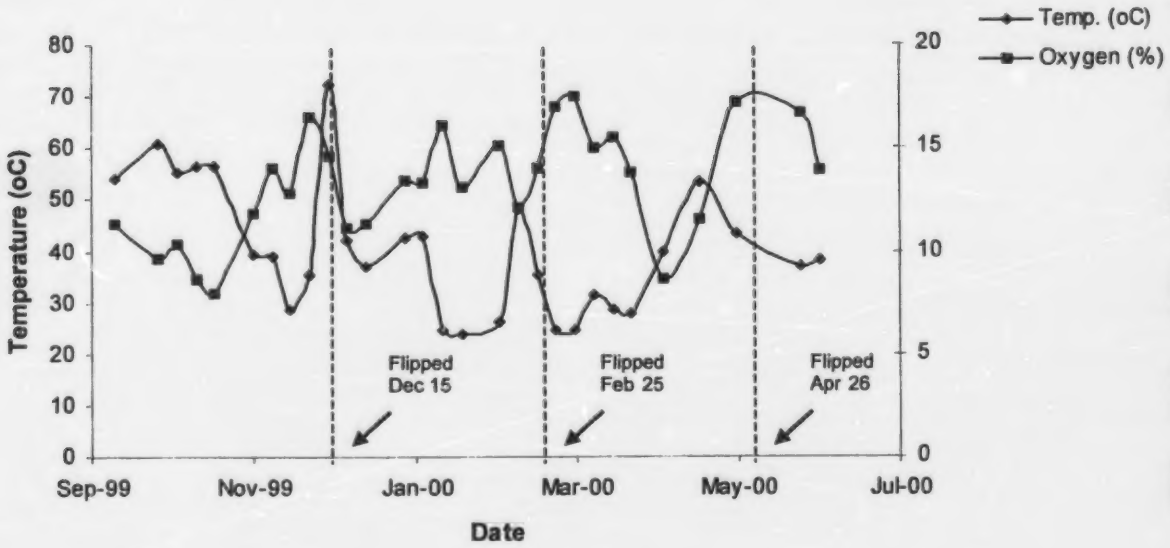


Figure 2. Manure/straw compost pile temperature and oxygen.

4.2 Volume Reduction

Deads I initially showed an increase in volume as deads were added, followed by a decrease in volume as degradation continued. Carcasses were added once a week to the Deads I pile from October 1999 to February 2000 when Deads II construction began. Volume increased due to the addition of new deads to the pile before the deads, already within the pile, were broken down. Once the pile was completed the incorporated deads were allowed to decay and a volume reduction was observed. Deads I pile volume results can be seen in Figure 3. Deads I volume reduction was estimated to be 40 – 50% from May 2000 to September 2000. For comparison, the straw/manure pile volume measurements, as seen in Figure 4, showed similar significant reduction during the composting period. Over the entire composting period pile measurement observation showed that the straw manure pile volume reduced by an estimated 50-60% of the original.

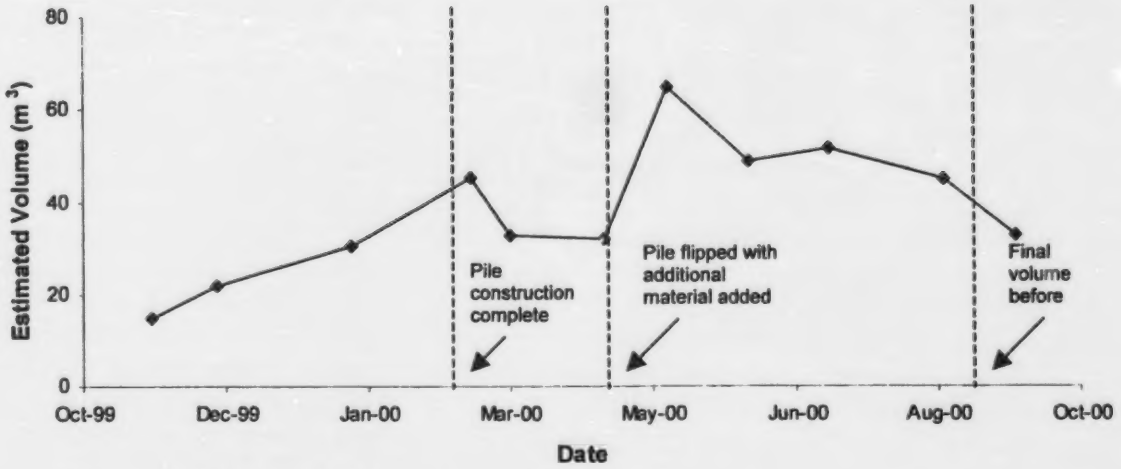


Figure 3. Deads I pile volume measurements.

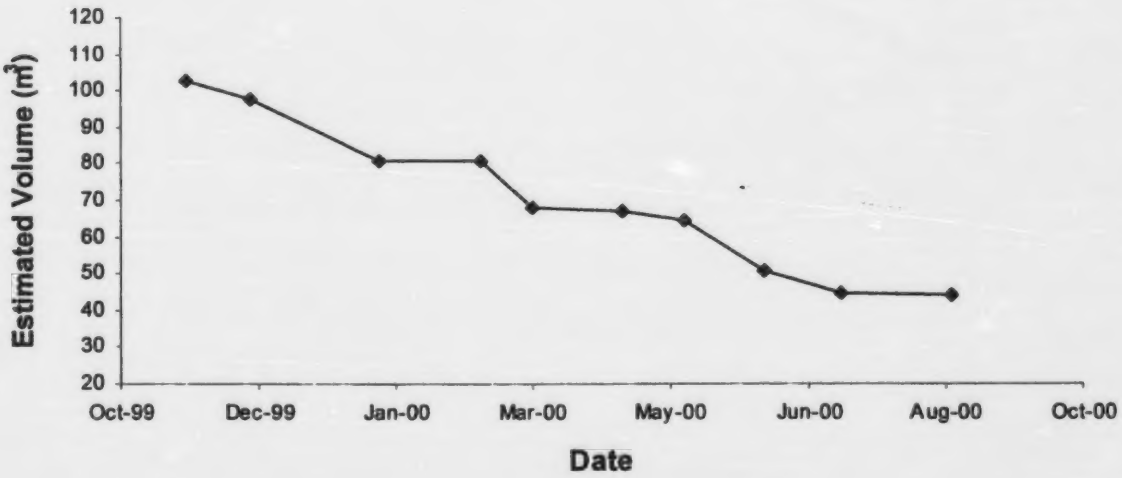


Figure 4. Straw/manure compost pile volume measurements.

4.3 Nutrient Values

Macronutrient value results on the original manure/straw used for base and as cover, the finished manure/straw pile and the screened Deads I compost are found in Figure 5. The nutrients were found to increase in the Deads I finished compost indicating that the addition of mortalities into the manure/straw mix may increase the value of the compost as a soil amendment.

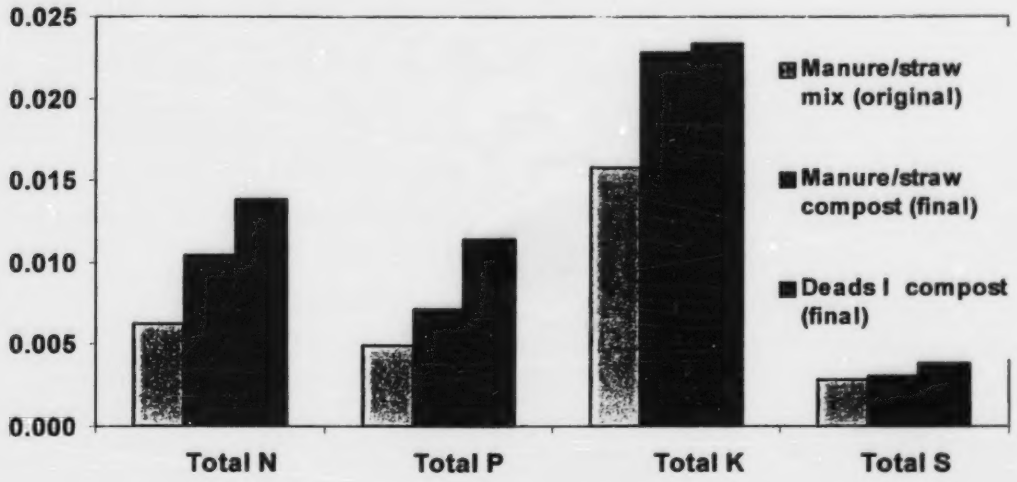


Figure 5. Macronutrient values found in original manure straw mix, finished manure/straw compost and Deads I finished. compost piles.

The C:N ratios, found in Figure 6 shows the degradation of carbon as a result of the composting process. The original C:N ratio of the manure straw from the shelters started at a value of 68 which is slightly higher than ideal, but is still an acceptable value for compost process initiation. The finished compost displayed a value 19 to 20 which shows that the composting process has stabilized with the utilization of available C.

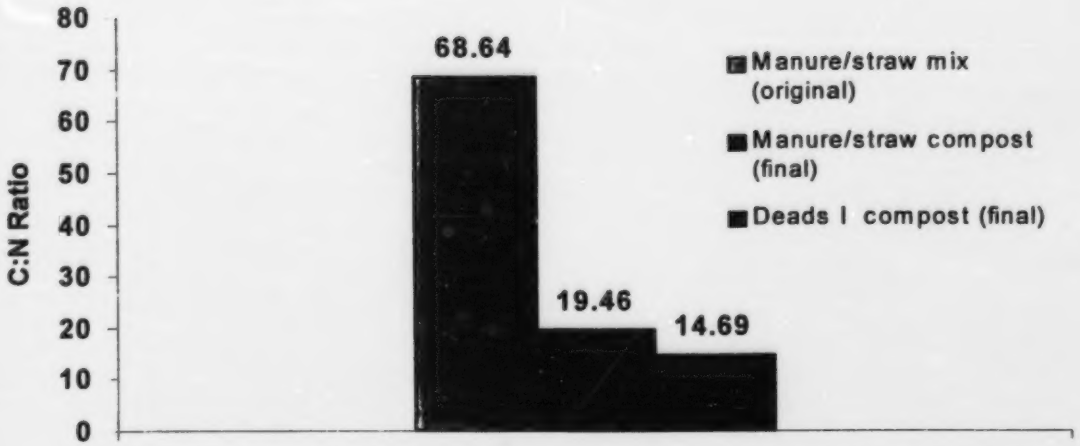


Figure 6. C:N ratios: manure/straw original, manure/straw finished and Deads I finished compost.

4.4 Moisture Content

Moisture contents in all piles thus far have approximately all fallen within the ideal range of 40- 65% moisture by weight without any effort from the researchers or the producer. Sufficient moisture values can be attributed to the initial moisture content of the carcasses (> 70%), the manure/straw covering (50-70%) and some precipitation. Figure 7 shows moisture contents data collected from the first four deads piles and the manure/straw pile.

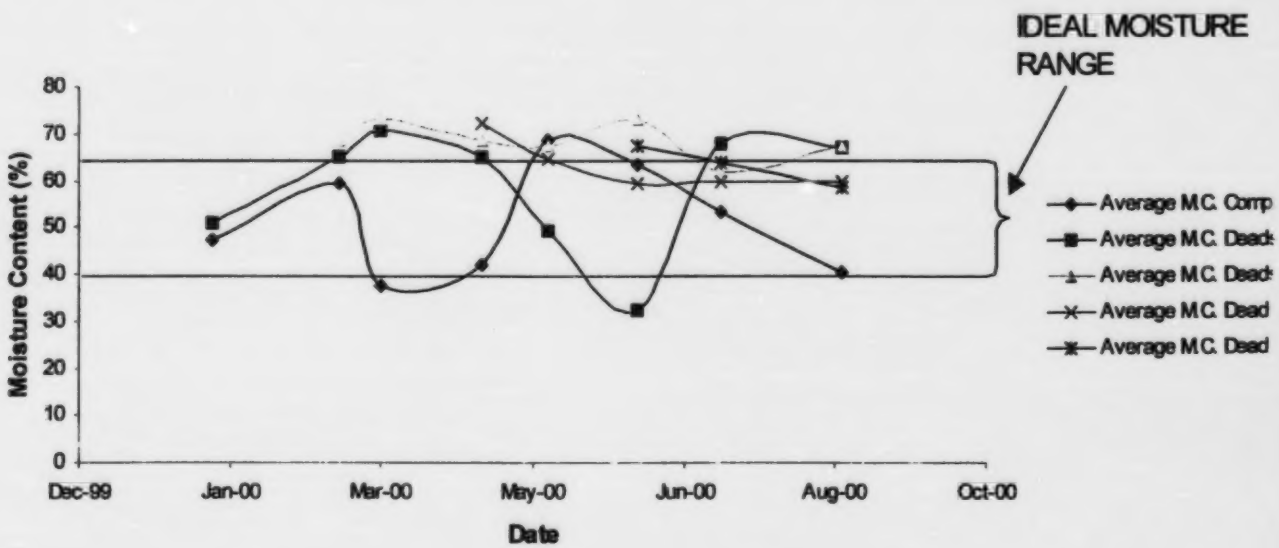


Figure 7. Moisture content values for all four deads compost piles.

4.5 Deads I Compost Screening

Approximately 11.5 m^3 of the Deads I compost pile weighing 3900 kg (dry basis) was screened to evaluate the amount of material that had not been composted. Materials that were ejected from the screen were primarily bone fragments that were not greater than 15 cm long, having a brittle to spongy texture (Photos 16 & 17). The total weight of objectionable materials was 1.5 kg (dry basis) resulting in a total of 0.04% material that were recognizable remains. The remains did not appear to have any severely threatening characteristics that would possibly cause damage to equipment. Results from screening of Deads I indicates that the composting process was successful in the decomposition of carcasses.

CONCLUSIONS

Composting mortalities as a method of dead animal management on a commercial hog operation in Saskatchewan has shown to be quite successful. Results show that carcasses can be effectively disposed of with minimal effort from the producer. Information from this study will help to establish guidelines and protocols for producers in Saskatchewan to follow for establishment of a composting program on their operation.

Composting manure has shown to benefit the producer by reducing the volume to be transported, resulting in a concentration of nutrients into a smaller mass thus reducing costs. Composting mortalities has increased the value of the compost as a soil amendment by increasing the amount of nutrients found within the compost with no apparent threat to field equipment from uncomposted remains.

The producer of this operation is quite satisfied with the results and plans to continue composting mortalities in the future. He stated that this method did not take any additional time compared to his former disposal method and that the operation is considering investing in equipment to accommodate the process such as a manure spreader and possibly a windrow turner to expand compost production.

FURTHER DEVELOPMENT

We feel it would be beneficial to ample and screen more compost from the continued operation in the spring of 2001 to establish if the controlled conditions of the research program had any effect on the results. Additionally, we feel that there is enough information to develop a "factsheet" that could be utilized by other producers.

PROJECT DEVELOPED MATERIALS

Composting Council of Canada
A paper and 15 minute oral presentation explaining the results and the ADF project Evaluation and Demonstration of Deads Composting as an Option for Dead Animal Management in Saskatchewan was given at the Composting Council of Canada's 10th Annual Composting Conference in Edmonton, Alberta September 2000. This project was selected to be a part of the session *Composting's Role in Livestock Management* (see Appendix B & C).

Saskatchewan Agriculture and Food
Presentations of the project Evaluation and Demonstration of Deads Composting as an Option for Dead Animal Management in Saskatchewan have been given to representatives from Saskatchewan Agriculture and Food for the purpose of project progression.

ACKNOWLEDGEMENTS

We would like to thank Cover-All Building Systems, Henry Quiring and staff at Marvel Acres Hog Farm and Pork Central for their cooperation and as well, the Saskatchewan Agricultural Development Fund for providing funding for the project.

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APPENDIX A

PROJECT PHOTOS

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Photo 1. Covered shelters of compost site.

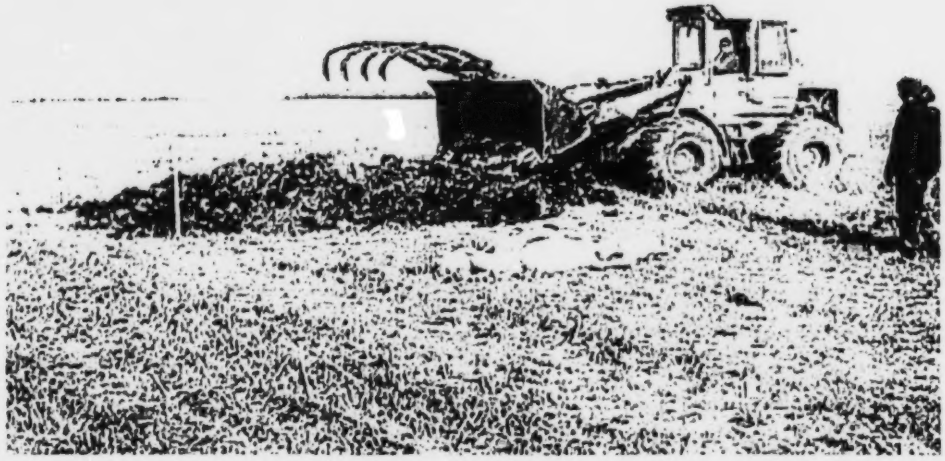

Photo 2. Deads I initial construction. October 1999.

Photo 3. Deads I pile construction complete, October 1999 (Control pile composed of manure/straw pile shown in background).

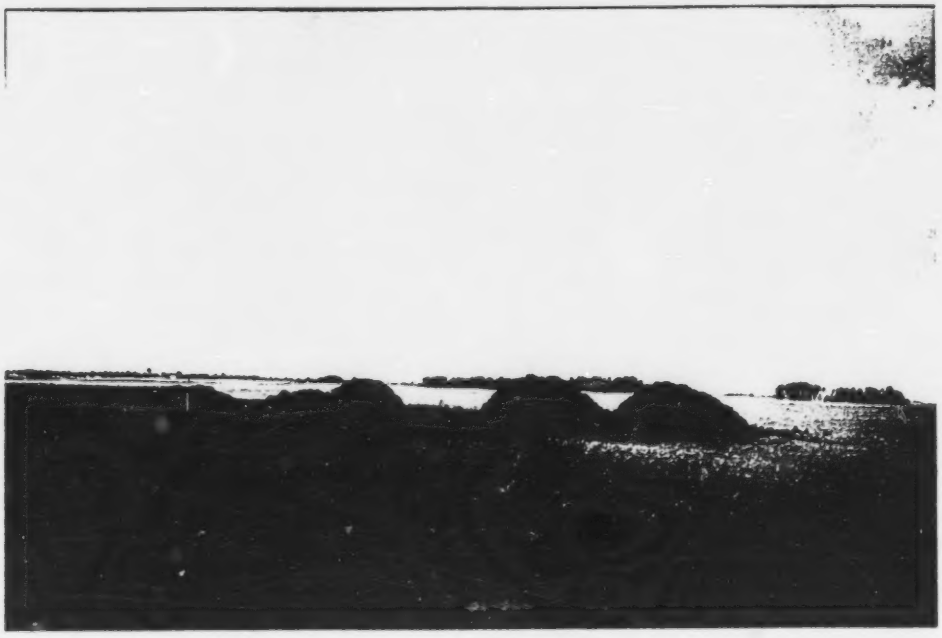

Photo 4. Deads compost piles near completion of project, August 2000.

Photo 5. Temperature and oxygen monitoring using probe on deads compost pile.

Photo 6. Deads I pile aeration, April 2000.

Photo 7. Compost sample collection for moisture content and bulk density analysis.

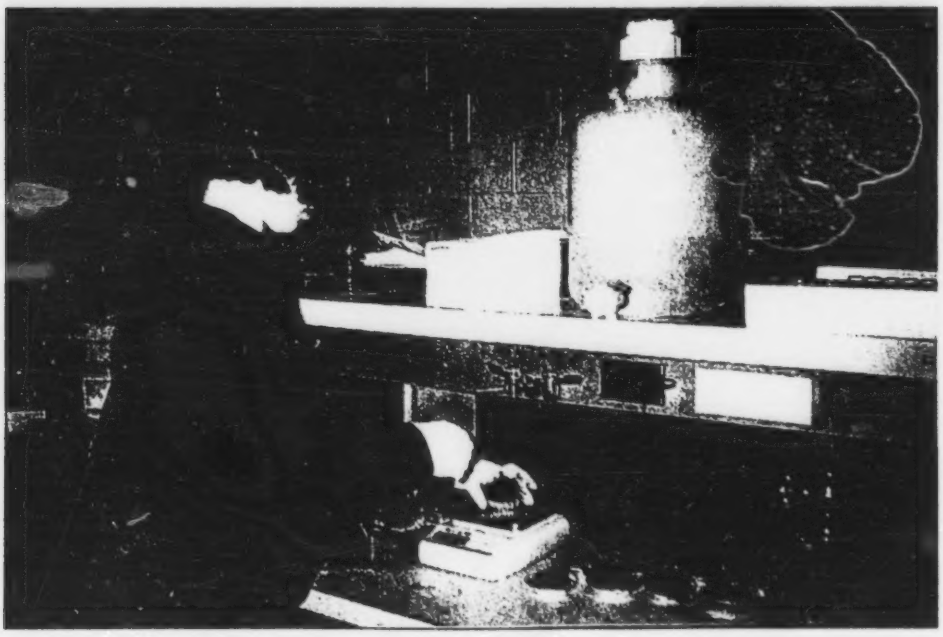

Photo 8. Laboratory analysis of compost samples.

Photo 9. Loading Deads I into tandem truck for transport to screening operation.

Photo10. Screening Deads I compost at commercial screening operation.

Photo 11. Separating uncomposted remains (tailings) from screened compost.

Photo 12. Total tailings recovered from screened compost before oven-drying.

Photo 13. An example of bone fragment found inside Deads I compost pile during first pile aeration, April 2000.
*Note size compared to human foot found on right.

Photo 14. Example of soft pulpy remains found inside Deads I compost pile during first pile aeration, April 2000.

Photo 15. Inside Deads I compost pile during second aeration, August 2000.

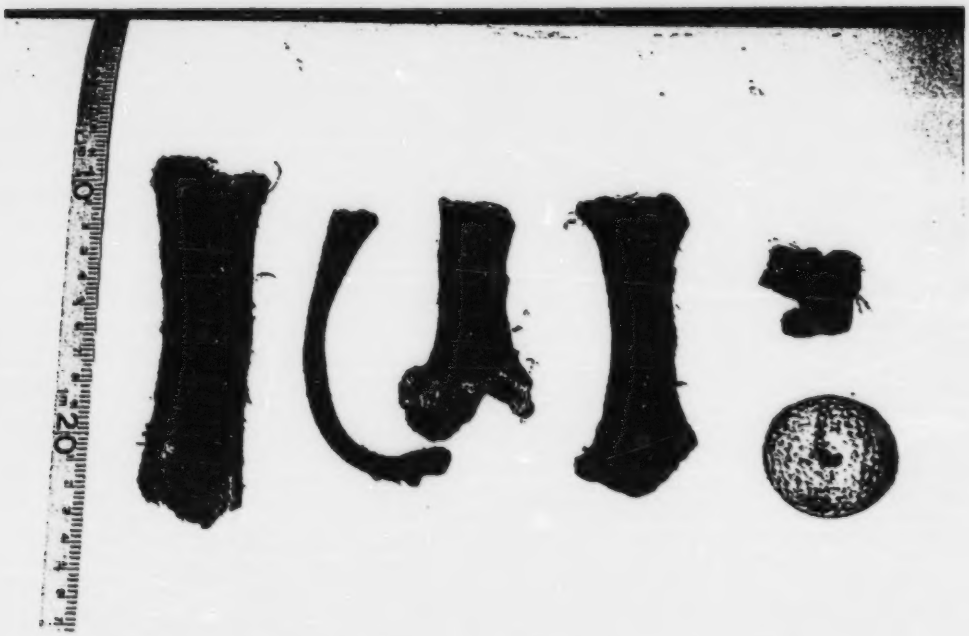

Photo 16. Range of tailings sizes recovered from screened compost.

Photo 17. Example of larger pieces of tailings recovered from screened compost.

APPENDIX B

CONFERENCE PAPER

Prepared For:
Compost Council of Canada 10th Anuual Conference
Edmonton, Alta., September 2000

Evaluation and Demonstration of Deads Composting as an Option for Dead Animal Management in Saskatchewan

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Pork producers in Saskatchewan are continuously looking for new developments that are both economic and environmentally sustainable. Composting is a potential option to for dead animal management which may meet both requirements. The purpose of this investigation is to determine whether or not composting is a viable option for dead animal disposal for hog producers in Saskatchewan. The test compost pile containing the mortalities (deads pile) consists of a straw/manure mix that is provided by animal shelters of the operation with deads added to this mix in increments of 10-14 days. An additional compost pile composed of straw/manure mix was constructed for the purpose of examining the potential for volume reduction. Temperature, oxygen, volume reduction and moisture conditions were monitored to track microbial activity and to evaluate the overall progress and efficiency of the composting mortalities. Observations of the deads composting pile during pile aeration has revealed that the carcasses have broken down successfully. This was verified when the deads compost pile was screened revealing a minimal amount of uncomposted materials.

INTRODUCTION

The expansion of the hog industry in Saskatchewan has created the need for new advancements to develop an economically and environmentally sustainable industry. Dead animal management is just one area of the livestock industry that producers need to be mindful of. Faced with increasing costs, concerns about environmental pollution and disease transmission, livestock producers and environmental officials are seeking more sustainable options for on-farm disposal of dead stock (Glanville 1994).

Dead Animal Management in Saskatchewan

Traditional methods used for dead animal disposal in Saskatchewan include rendering, incineration and burying. Rendering is a method in which dead stock is picked up at the production site and transported to a rendering facility where carcasses are recycled into useful byproducts. Due to the limited number of rendering facilities in Western Canada and the cost potential for transportation, the volume of carcasses produced determines if rendering is the most economic disposal option. Biosecurity is also a concern regarding this type of facility as the transport trucks traveling between many locations in a trip, thus increasing the risk of herd contamination.

Burying is a common method of disposal that has been long accepted in Saskatchewan. Regulations state that animal remains may be buried, however the bottom of the pit must be at least 1 m above any water bearing formation and the carcasses must be covered with a minimum 0.6 m of soil. The burial pit must be located in a medium to fine textured soil, away from areas subject to flooding and at least 90 m away from a watercourse, a body of water or a water well (SAF 2000). Burial as a method of disposal in Saskatchewan can prove to be difficult for producers during winter months when the ground is frozen. Larger hog operations may have refrigeration facilities on site to store deads in order to accumulated a large enough number that would be economical for transport. Refrigeration is usually associated with eventual disposal to a rendering plant, but may also be used for storage during winter months when burial is not possible.

Incineration of mortalities is a method that is used in Saskatchewan, but is carefully monitored to ensure that proper procedures are followed. In this province, Saskatchewan Environment and Resource Management requires producers to have a license enabling them to install and operate an incinerator. Economics must also be considered when choosing this type of disposal method since incineration requires a great deal of energy to fully complete the process.

Composting is a natural process where microorganisms decompose organic material in a primarily aerobic environment (Rynk 1992 and Haug 1993). Microorganisms consume oxygen for fuel as they feed on organic matter resulting in a metabolic release of heat, carbon dioxide (CO_2) and water vapor into the air. Carbon dioxide and water can contribute up to half the weight of the raw materials therefore the loss of these two components can cause significant volume and mass reduction (Rynk et al. 1992). At present, composting in the food processing and agriculture industries has great potential to be an environmentally sound method to manage waste produced while generating a useful soil amendment as the final end product. Composting as a method of dead animal disposal in Saskatchewan has been primarily used for poultry and smaller animals. Preliminary research and field studies suggest that mortalities from hog operations may also be successfully composted.

Composting Swine Mortalities

Composting has proven to be an environmentally sustainable method to dispose of swine carcasses and has been accepted in many areas of the world (Fulhange and Ellis 1997). Due to their inconsistent nature, composting swine carcasses is unlike typical composting where materials are thoroughly mixed to ensure proper distribution. The pile in this case consists of a large bulk of material, the carcass, which has a low C/N ratio, low porosity and high moisture content encompassed by the carbon amendment, a material which has a high C/N ratio, good porosity and moderate moisture. Initial decomposition is anaerobic in and around the carcass, however as the decomposition process continues gases and liquids are released, they diffuse away from the area and are trapped in the aerobic zone of the surrounding material. Microorganisms within this zone ingest and degrade the gases into CO_2 and water vapor (Keener et al. 1999). The compost pile is not turned until

decomposition of the carcasses has been completed. For swine, this period is approximately 3 months after the last pig has been placed on the pile. The pile is then turned, incorporating oxygen into the mix to further fuel microbial activity and an additional 3 months is required to allow the compost to cure. A study conducted in South Carolina has shown within a 5 month time period, all that remained of a 295 kg, 10 year old boar was a dark humus like material and some large bones and teeth (Henry 1995).

Composting Swine Manure

Research using straw/manure has shown composting can be accomplished but may require a longer period of time when compared with using sawdust as a carbon source (Pittaway 1998, Morris et al. 1998). Swine manure independently has been classified as being nitrogen-rich with a high moisture content making it slightly more difficult to compost relative to other livestock manures. Odor is also a concern with this form of waste. Straw incorporated into the swine manure will improve its compostability by lowering the moisture content, increasing the carbon content and by providing some odor control (Rynk 1992).

Factors Affecting Composting

Temperature and Oxygen

Temperature and oxygen content within the compost pile are key indicators of the progress of the composting process since the release of heat and the consumption of oxygen is directly related to microbial activity. All organisms have a temperature and oxygen range in which they can function optimally thus initiating and sustaining biochemical reactions. Monitoring oxygen and temperature values throughout the composting process is essential to ensure a successful end result.

Composting process temperatures generally follow a pattern that begins with the active composting stage where a rapid increase in temperature to around 50 - 60°C occurs as readily available compounds are ingested. Thermophillic bacteria that thrive in this temperature range are found to be the most efficient at decomposing material in a composting environment (Henry 1995). The temperature remains in this zone for several weeks. Oxygen supplies may become depleted during the active composting period thus slowing down activity resulting in a decrease in temperature. A minimum of at least 5% oxygen is required to maintain activity. Aeration, accomplished by pile turning or by method of forced aeration, is necessary to replenish supplies to recommence activity as well as remove water vapor and other gases that may be trapped within the pile. If conditions are especially favorable for microbial degradation, activity is intense and the temperature may rise well above 60°C. For every 10°C rise in temperature, the rate of biochemical activity is found to double. However, temperatures to the high or low extremes may limit the process kinetics (Haug 1993). Temperatures in the range of 75 - 85°C are likely depressing activity since microorganisms die or become dormant in extreme temperatures and aeration is required to cool the pile (Rynk 1992 and Haug 1993).

As decaying activity slows, the compost enters the curing stage and a drop in temperature to approximately 30 - 40°C is noticed, followed by a gradual decrease to ambient air temperature as the process stabilizes. The rate of oxygen consumption slows therefore aeration is not essential during the curing stage. The composting process does not have a definite endpoint, microorganisms will continue to biodegrade organic compounds until all remaining nutrients are consumed and all carbon is converted to CO_2. Cured compost becomes stable having a dark brown to black color, an earthy odor and a temperature which eventually equals that of ambient conditions. Once the compost has cured for the required amount of time, it may be incorporated into the producers manure management plan or marketed as a soil amendment.

Nutrients

Nutrients, mainly carbon (C), nitrogen (N), phosphorus (P) and potassium (K) are required by microorganisms driving the composting process to support biological action. As well, the value of the finished compost is largely predicted by nutrient concentrations since N, P and K are the chief nutrients used by plants. Nitrogen and C are especially important since C provides energy and growth for microorganisms while N is necessary for protein development and cellular reproduction. A ratio of carbon to nitrogen (C:N) has been adopted by the composting industry as a measure of a suitable nitrogen balance, and as a method to ensure that other required nutrients are present in appropriate amounts. For the purpose of composting, raw materials blended to achieve a C:N ratio between 25 and 30 (25:1 and 30:1) has been reported to be ideal, although ratios above 50 have been reported to be effective but require a longer composting period for complete carbon utilization (Haug 1993 and Rynk 1992). A C:N ratio below 20 indicates that the available carbon has been utilized and converted to CO_2, and the remaining unstable nitrogen may be lost as ammonia (NH_3) or nitrous oxide (N_2O) which may result in unpleasant odors. Odor can therefore be controlled in the composting process if there is a proper C:N ratio which will provide enough carbon to ensure that the majority of nitrogen will be stabilized.

A typical nutrient profile for swine manure in Saskatchewan is found in Table 1. Cereal grain straw is found to contain a C:N ratio ranging from 128-150 (Haug 1993). The resulting mixture of these two raw materials will provide a sufficient mixture for mortality composting.

Table 1. Average nutrient values for swine manure in Saskatchewan

Nutrient	Type of Manure	
	Liquid Swine (kg/1000 L)	Solid Swine (kg/tonne)
Nitrogen (N)	3.0	8.4
Phosphorus (P)	0.9	4.6
Potassium (K)	1.0	10.8
Sulphur (S)	0.4	3.2

(SAF 1999)

Moisture Content

Moisture levels are important in a composting operation. Water acts as a media to support the metabolic activity of the microorganisms. A moisture content of 40 – 70% by weight is recommended for optimum activity in most materials (Shuler 1980, Rynk 1992 and Haug 1993). Below a level of 40% moisture content degradation continues to slow and at a moisture content of 15%, activity ceases entirely. At levels above 70%, water begins to inhibit the flow of oxygen by lowering the free air pore space within the pile affecting the balance of elements needed by microorganisms to thrive. Moisture values naturally present in swine carcasses should be sufficient for composting without an additional moisture source since the tissue of swine is found to have a moisture content greater than 70% (Pittaway 1998).

Composting Swine Mortalities in Saskatchewan

Composting swine mortalities has great potential to be a method of dead animal management on hog operations in Saskatchewan. Manure is generally readily available and animal deaths are inevitable. Table 2 shows volume of manure produced and number of deaths expected on a typical hog operation in Saskatchewan. With the incorporation of a bulking agent, such as straw, composting can be a solution for dead animal management that uses readily available materials is economical, environmentally sustainable and produces a useful end product.

Table 2. Swine manure production and expected animal losses in Saskatchewan

Animal Type	Daily Manure Production for Storage		Average Death Loss (% per cycle)	Cycles per Year
	Solid (kg/animal/day)	Liquid (l /animal /day)		
Boars and gestating sows (150 kg av)	21.1	15.9	3	1
Nursing sows (150 kg av)	29.0	21.8	3	1
Gilts (125 kg)	16.9	12.7	1	1
Feeder pigs (100 kg)	11.3	8.5	1	3
Weanling pigs (16 kg)	2.1	1.6	1.5	6

(SAF 2000)

The objective of this project was to determine the viability of composting as a method of dead animal disposal for hog producers in Saskatchewan. This management option was demonstrated and analyzed on a commercial hog operation over a two year period. Results from this study will help to establish guidelines and protocols for producers to help implement this practice of disposal in Saskatchewan.

MATERIALS AND METHODS

Compost Pile Construction

The initial deads compost pile was constructed October 1999 at Marval Acres Stock Farms, Hepburn, Saskatchewan. This particular operation is a 350 farrow to finish where finishing takes place in a series of 14 covered shelters which use straw as bedding for the animals. The pile was constructed in a field near the operation where enough room was available for pile turning and for the producer's machinery to easily access the piles. The estimated area that was be used for composting is approximately 1000 m^2. Deads compost pile construction was modeled after the method described by Keener et al. (1998). The initial deads compost pile (labeled Deads I) was built by constructing a manure/straw mix base approximately 0.6 m thick with an area of 4m x 6m to accommodate the producer's available equipment. A group of deads was placed on the base, laid side by side, totaling approximately 145 kg and covered by a layer of straw/manure mix 0.6 m thick. A second group of deads, totaling 128 kg was laid beside the first group and again covered by a layer of manure/straw. Samples of the covering and base were collected for a baseline nutrient analysis. This method of pile construction continued until early February 2000 when a new pile was started. The initial deads composting pile incorporated a total of 2845 kg of swine mortalities. Additional deads piles have been constructed as the previous piles reach a limit of approximately 2000 – 2500 kg of carcasses using the method consistent with that used for Deads I. To date there are five deads compost piles in total.

A pile consisting of a straw/manure mix only was constructed at the same time as Deads I (October 1999) as a control and to investigate the volume reduction potential of composting swine manure in Saskatchewan conditions. This pile was monitored using the same methods as the deads piles. The manure/straw pile continued to compost until August 2000, when it was concluded that this pile was finished and ready to be land applied.

Compost Pile Monitoring

Oxygen, temperature, volume, bulk density and moisture content were monitored throughout the study on all piles to track the composting progress. Temperature and oxygen readings were taken once a week using Demista Instrument's Oxygen-Temperature Monitor (Model OT-21). This device consists of a probe 1.5 m long that penetrates the compost pile to measure both temperature (^{o}C) and oxygen (%). Temperature and oxygen measurements were taken in various positions in the piles to track the overall progress of microbial activity thus indicating when the piles required aerating. Pile aeration was accomplished by constructing a base of manure/straw 0.6 m thick and turning the pile onto this base using a front-end loader provided by the producer and recovering the pile with 0.6 m of the manure/straw mix from the shelters.

Volume reduction data was manually taken once a month using a standard 30 m measuring tape to obtain all piles' approximate dimensions. To further investigate volume reduction as well mass reduction, bulk density data was collected using the method described by Rynk (1992). Moisture data was obtained by collecting samples in airtight plastic bags once a month at various positions from each pile and oven drying them at a temperature of 105°C to obtain the overall average moisture content for each individual pile.

Deads I was screened in September 2000 to evaluate the amount of objectionable material that remained in the pile, i.e. any large bones or sharp fragments that may pose as a threat to machinery if the compost was to be land applied. A tandem truckload of Deads I was loaded at the site and transported to a commercial screening operation. The truck was weighed before and after the compost was loaded to determine the mass of compost that was to be screened. As screening took place, any recognizable remains were separated out for general observation as well as, to determine the mass of remaining material to compare to the mass of the total compost on a dry matter basis which will in turn evaluate the overall effectiveness of composting swine mortalities. All final samples of the screened compost, as well as samples of the final manure/straw compost were collected and taken to Enviro-Test Laboratories, Saskatoon, Saskatchewan for nutrient analysis.

RESULTS AND DISCUSSION

Temperature and Oxygen Monitoring

Because of the cool temperatures associated with the season in which Deads I was constructed, the active composting stage took place over a period of 6 months. According to the weekly oxygen and temperature readings, the rate of active composting began to speed up slightly during warmer ambient temperatures. Temperature and oxygen readings from October 1999 through September 2000 for Deads I are shown in Figure 1. The first month of readings demonstrates the initial "bloating" stage where decomposition is accomplished by microbes found within the carcasses. As the organic material becomes more readily available to the microbes in the manure/straw medium, the temperature increases and the oxygen consumption begins. This pattern can be seen as deads were added to the pile in approximately 10 – 14 day increments. Once Deads I pile was completed the temperature and oxygen began to follow a continuous pattern: temperature values decreased as the oxygen supplies were gradually depleted. Deads I was determined to be ready for aeration as the oxygen content approached the minimum of 5% and the temperature began to decrease below 40°C.

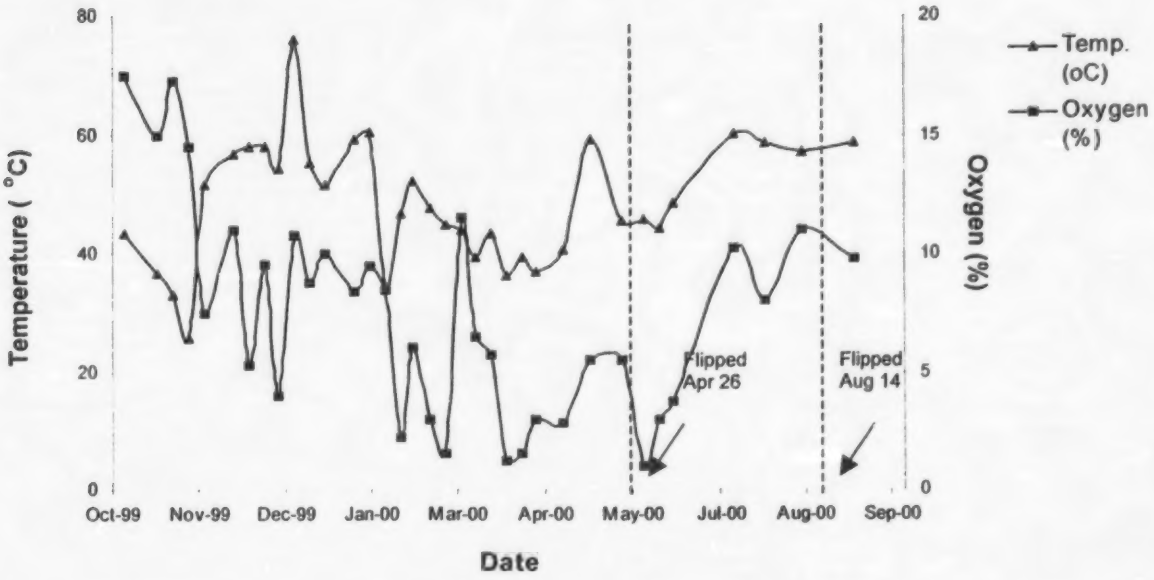

Figure 1. Deads I compost pile temperature and oxygen measurements

Deads I was flipped for the first time April 26, 2000. Observations taken during pile flipping showed that the decomposition of the swine mortalities was quite successful at this time. There was no evidence of large bones or of any recognizable portions of the carcasses that were added to the pile. The compost pile was a dark color emitting no offensive odors. Temperature and oxygen values rapidly recovered soon after pile aeration. Deads I continued to be monitored until it was flipped August 14, 2000 when oxygen and temperature values began to decrease and until it was screened September 12, 2000.

Temperature and oxygen readings for the straw/manure pile are seen in Figure 2. The initial activity in this pile commenced much more quickly than Deads I. This behavior is expected because of the more readily available organic matter in the straw/manure compared to swine carcasses. This pile was flipped for the first time on December 15, 1999 when temperature levels began to drop. Microbial activity was stimulated resulting in an increase in temperature. This pattern continued and the pile was flipped three more times during the composting period when probe readings indicated. A final sample of the compost was taken June 24, 2000 to compare the nutrients in the compost to the original material. Observations by the primary researcher concluded that this pile could be applied when land was available and when the producer was ready.

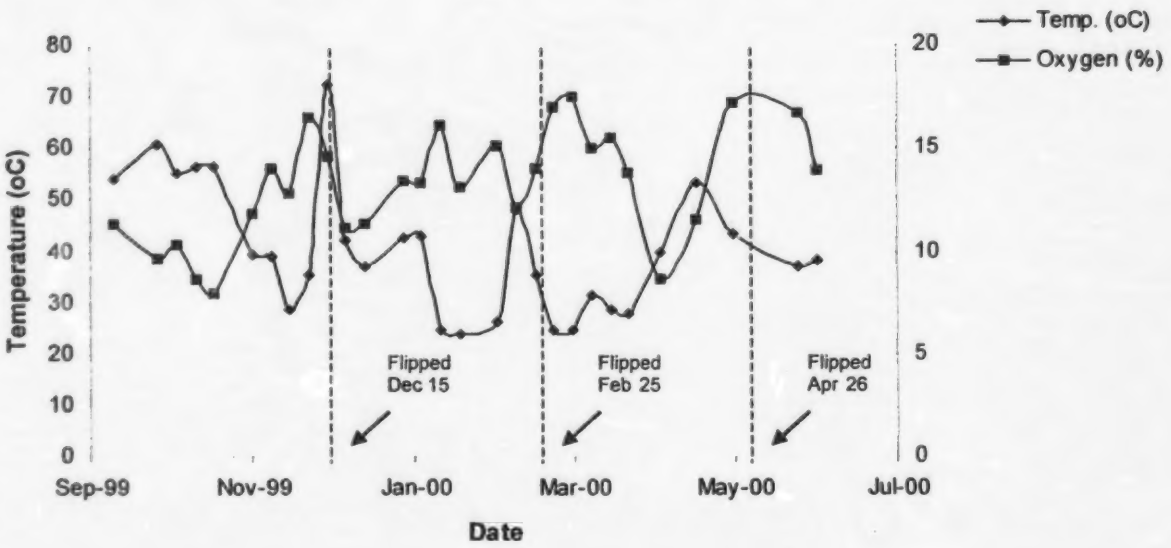

Figure 2. Manure/straw compost pile temperature and oxygen measurements

Volume Reduction

Deads I initially showed an increase in volume as deads were added, followed by a decrease in volume as degradation continued. Carcasses were added once a week to this pile until Deads II was constructed February 14, 2000. Volume increased due to the addition of new deads to the pile before the deads, already within the pile, were broken down. Once the pile was completed the incorporated deads were allowed to decay and a volume reduction was observed. Deads I pile volume results can be seen in Figure 3. The straw/manure pile volume measurements, as seen in Figure 4, showed significant reduction during the composting period. Over the entire composting period pile measurement observation showed that the straw manure pile volume reduced by an estimated 50-60% of the original. Bulk density measurements collected from each compost pile to further assess volume reduction were found to be inconclusive likely due to the inconsistent nature of the compost containing carcasses.

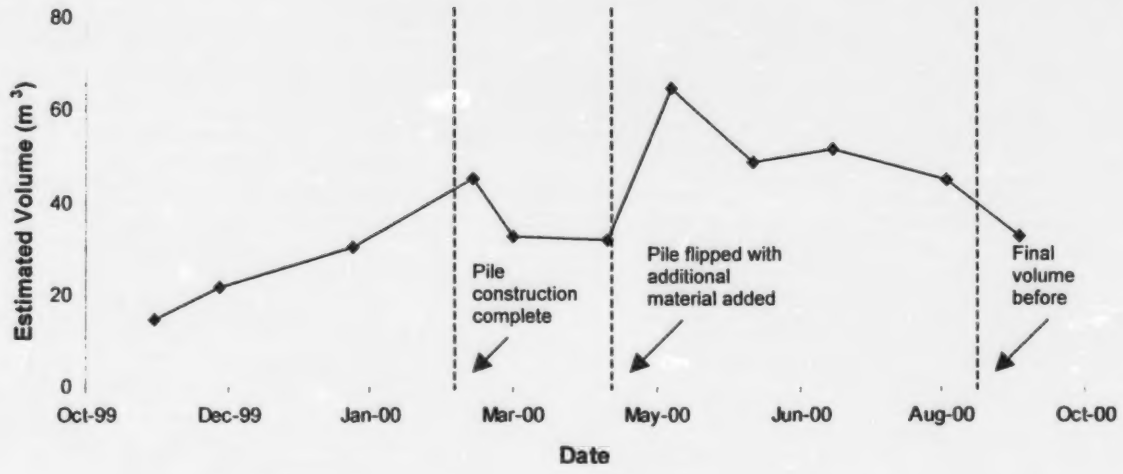

Figure 3. Deads I pile volume measurements

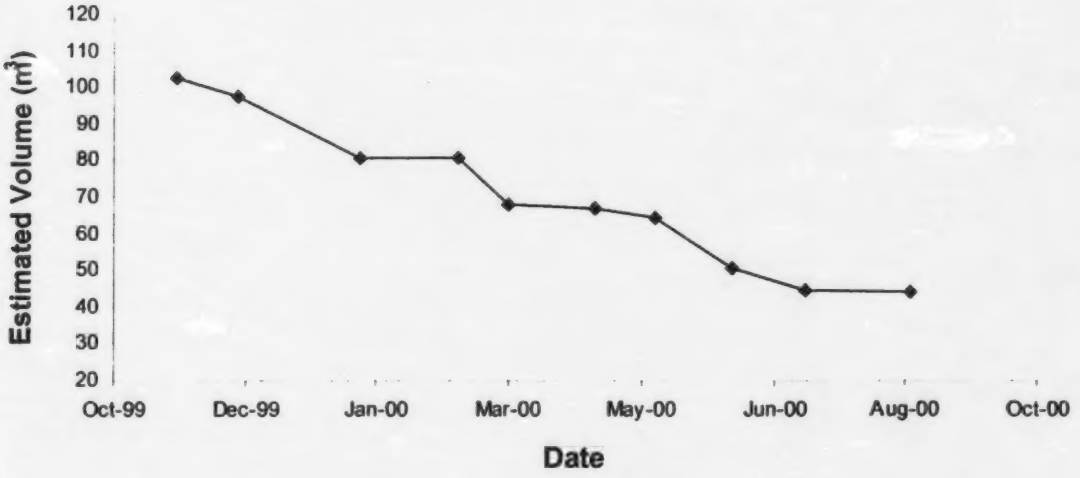

Figure 4. Straw/manure compost pile volume measurements

Nutrient Values

Macronutrient value results on the original manure/straw used for base and as cover, the finished manure/straw pile and the screened Deads I compost are found in Figure 5. The nutrients were found to increase in the Deads I finished compost indicating that the addition of mortalities into the manure/straw mix may increase the value of the compost as a soil amendment.

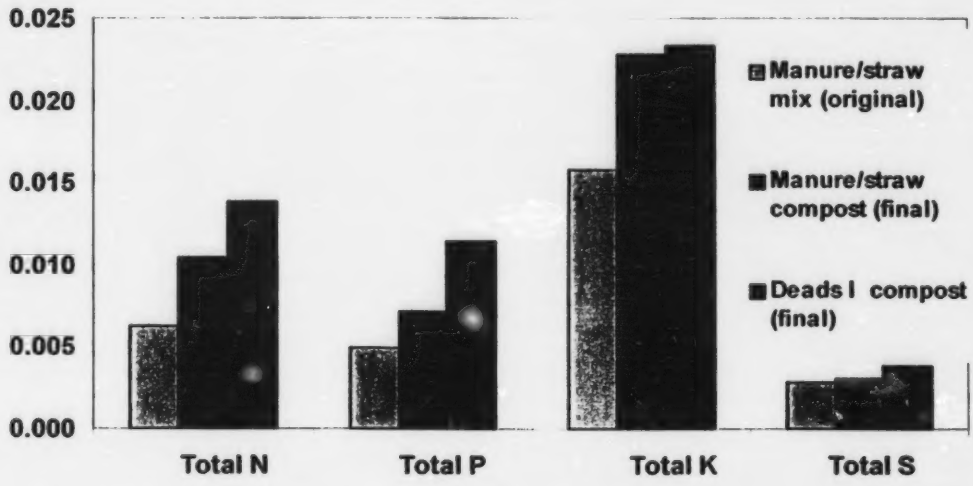

Figure 5. Macronutrient values found in original manure straw mix, finished manure/straw compost and Deads I finished compost piles

The C:N ratios, found in Figure 6 shows the degradation of carbon as a result of the composting process. The original C:N ratio of the manure straw from the shelters started at a value of 68 which is slightly higher than ideal, but is still an acceptable value for compost process initiation. The finished compost displayed a value 19 to 20 which shows that the composting process has stabilized with the utilization of available C.

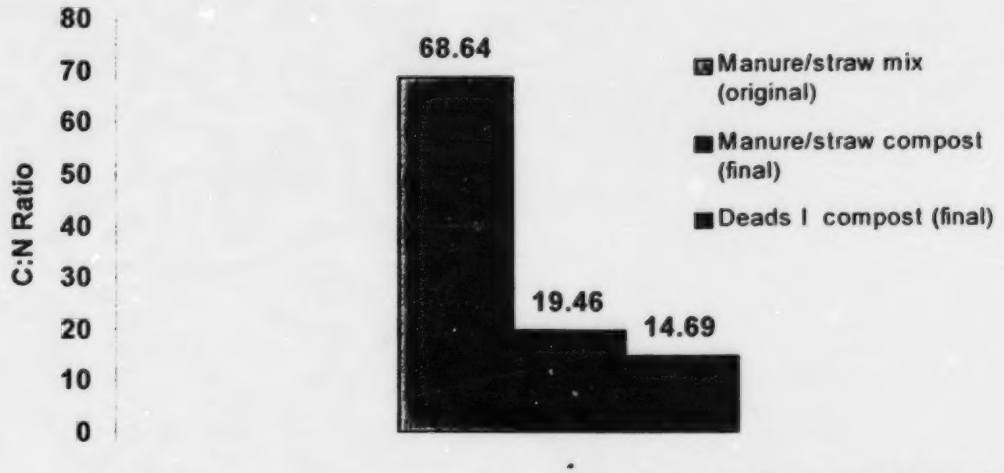

Figure 6. C:N ratios: manure/straw original, manure/straw finished and Deads I finished compost

Moisture Content

Moisture contents in all piles thus far have approximately all fallen within the ideal range of 40- 65% moisture by weight without any effort from the researchers or the producer. Sufficient moisture values can be attributed to the initial moisture content of the carcasses (> 70%), the manure/straw covering (50-70%) and some precipitation. Figure 7 shows moisture contents from four deads piles and the manure/straw pile.

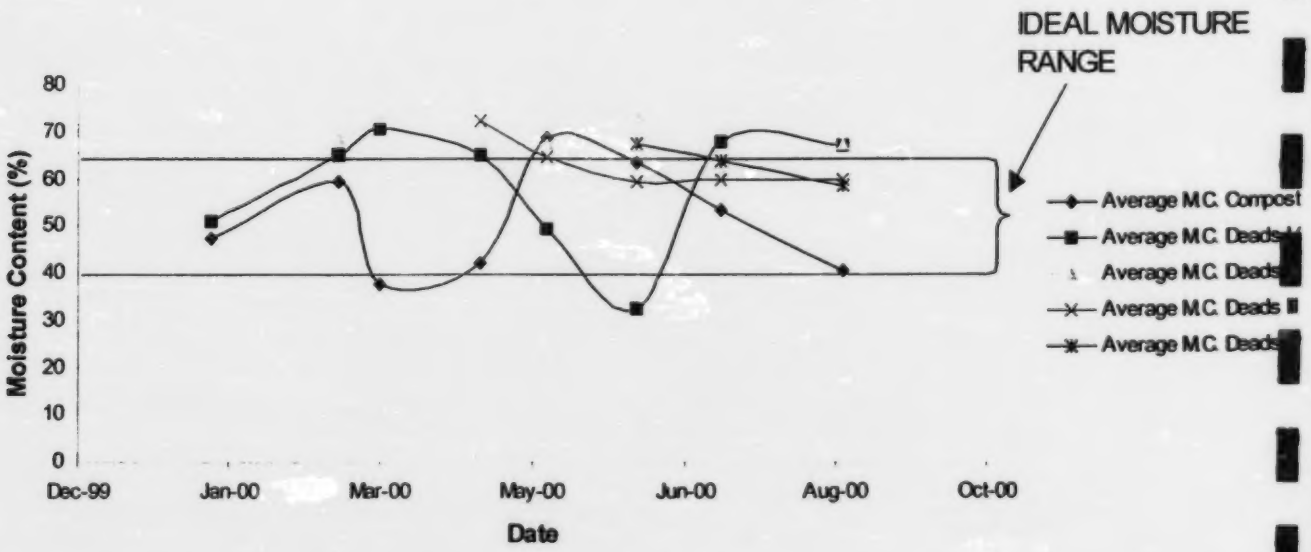

Figure 7. Moisture content values for all four deads compost piles

Deads I Screening

Approximately 11.5 m^3 of the Deads I compost pile weighing 3900 kg (dry basis) was screened to evaluate the amount of material that had not been composted. Materials that were ejected from the screen were bone fragments that were not greater than 15 cm long, having a brittle to spongy texture. The total weight of objectionable materials was 1.5 kg (dry basis) resulting in a total of 0.04% material that were recognizable remains. The remains did not have any severely threatening characteristics that would possibly cause damage to equipment. Results from screening of Deads I indicates that composting process was successful in the decomposition of carcasses.

CONCLUSIONS

Composting mortalities as a method of dead animal management on a commercial hog operation in Saskatchewan has shown to be quite successful. Results show that carcasses can be effectively disposed of with minimal effort from the producer. Information from this study will help to establish guidelines and protocols for producers in Saskatchewan to follow for establishment of a composting program on their operation.

Composting manure has shown to benefit the producer by reducing the volume to be disposed of, concentrating the nutrients into a smaller mass thus reducing transport costs. Composting mortalities has increased the value of the compost as a soil amendment by increasing the amount of nutrients found within the compost.

The producer of this operation is quite satisfied with the results and plans to continue composting mortalities. He stated that this method did not take any additional time compared to his former disposal method and that the operation is considering investing in equipment to accommodate the process such as a manure spreader and possibly a windrow turner to expand compost production.

ACKNOWLEDGEMENTS

We would like to thank Cover-All Building Systems and Henry Quiring and staff at Marvel Acres Hog Farm for their cooperation and the Saskatchewan Agricultural Development Fund for providing funding for the project.

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APPENDIX C

CONFERENCE PRESENTATION

Presented At:
Compost Council of Canada 10th Anuual Conference
Edmonton, Alta., September 2000

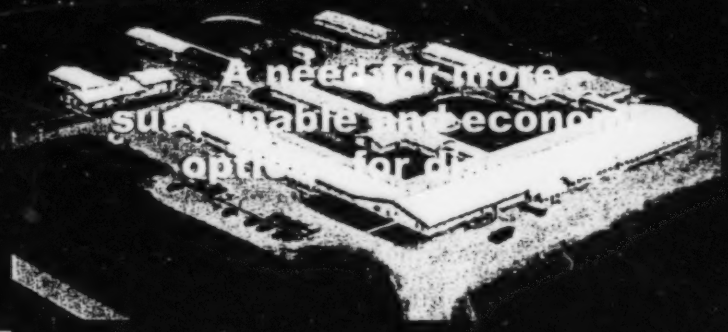
Evaluation and Demonstration of Deads Composting as an Option for Dead Animal Management in Saskatchewan

T. A. Fonstad[1], J. Leonard[2], D.E. Meier[1], L. J. Ingram[1]

1. Department of Agriculture and Bioresource Engineering University of Saskatchewan
2. Department of Agricultural, Food and Nutritional Sceince, University of Alberta

Background

Expansion in the Industry



A need for more sustainable and economic options for disposal

Dead Animal Management in Saskatchewan

- Rendering
- Incineration
- Burying
- Composting

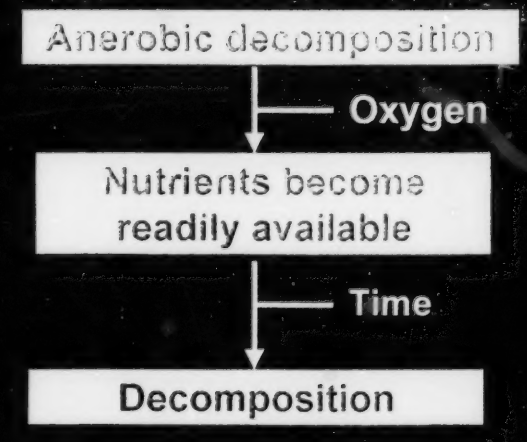
Burial

- Bottom of pit above groundwater
- Medium to fine textured soil
- Carcasses must be covered by 0.6 m of soil
- 90 m away from water body (SAF 2001)

Composting Mortalities

- A method around the world used more recently with expanding industry
- Mortalities composting process

Composting Mortalities

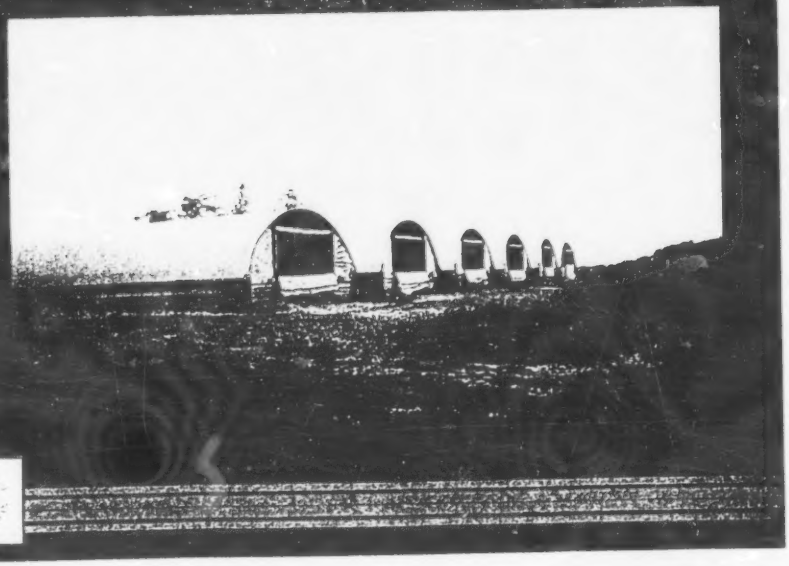


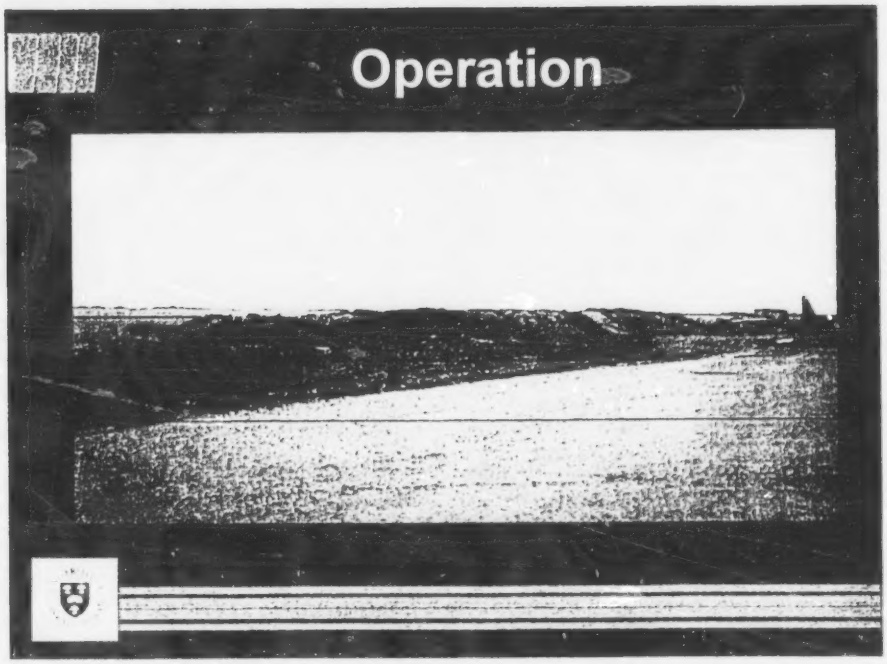
Fonstad et al. 2001

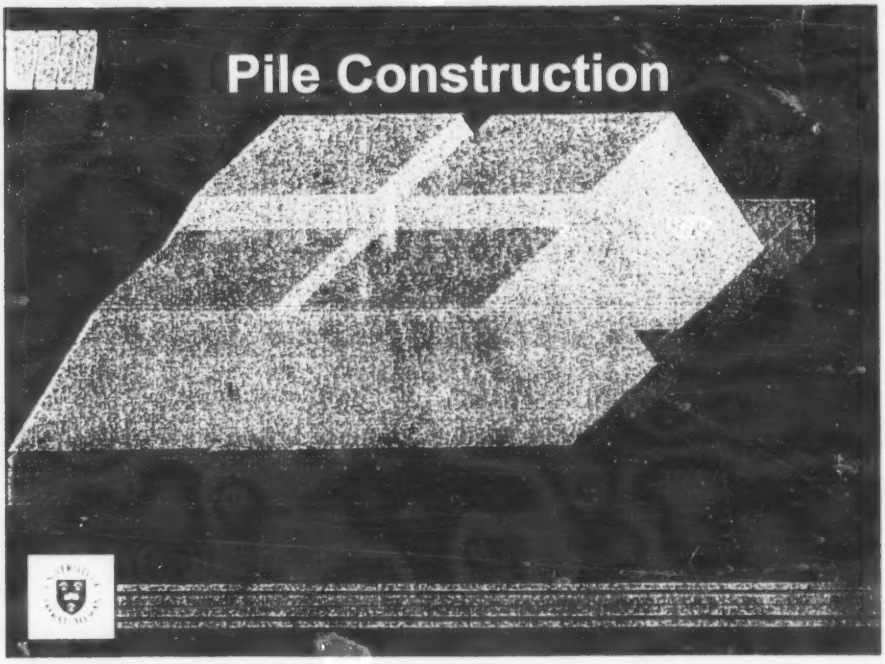
Objectives

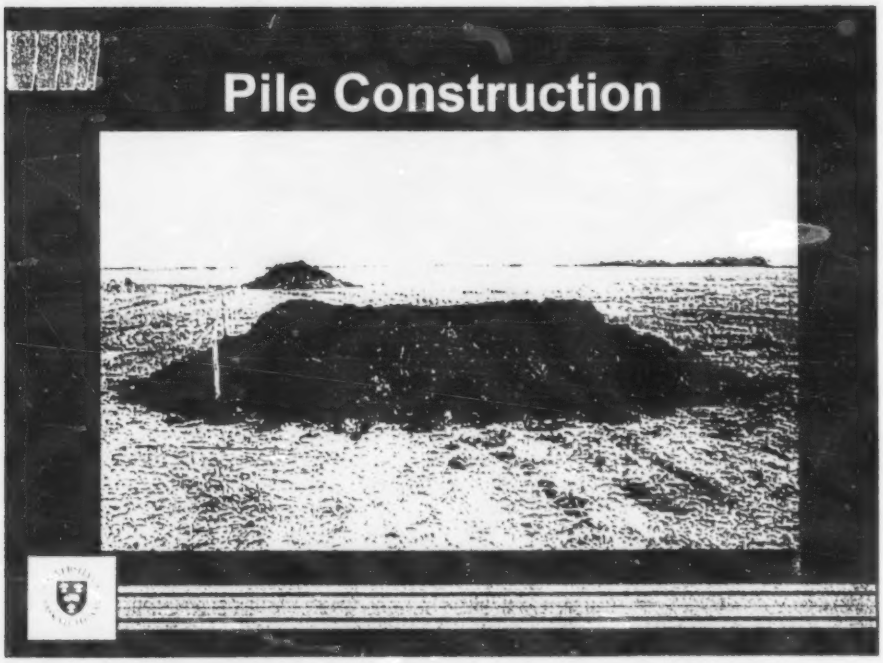
- To determine the viability of composting as a method of dead animal disposal for Saskatchewan hog producers
- To use data to help to establish guidelines for future composting efforts

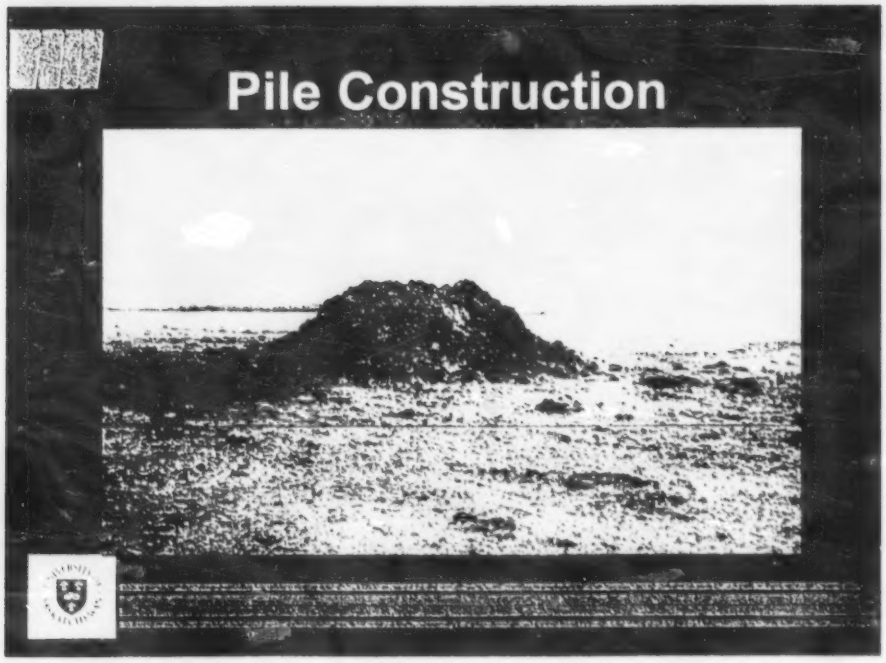
Operation




Operation


Pile Construction


Pile Construction


Pile Construction

Monitoring

- Temperature and Oxygen
- Moisture Content
- Volume
- Nutrients

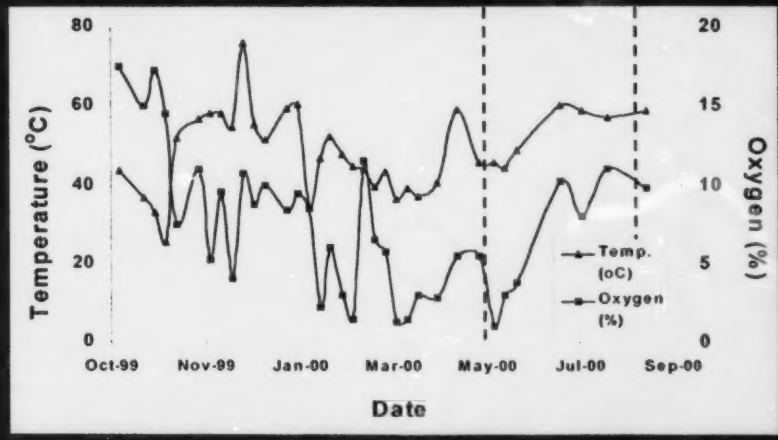
Monitoring

Monitoring

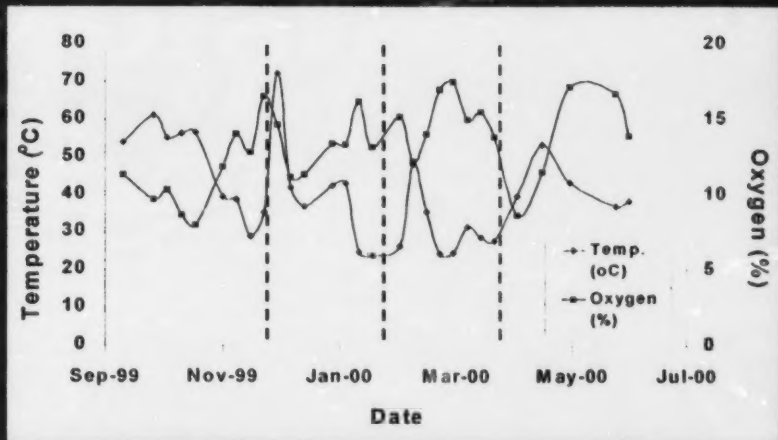
- Temperature and Oxygen
- Moisture Content
- Volume
- Nutrients

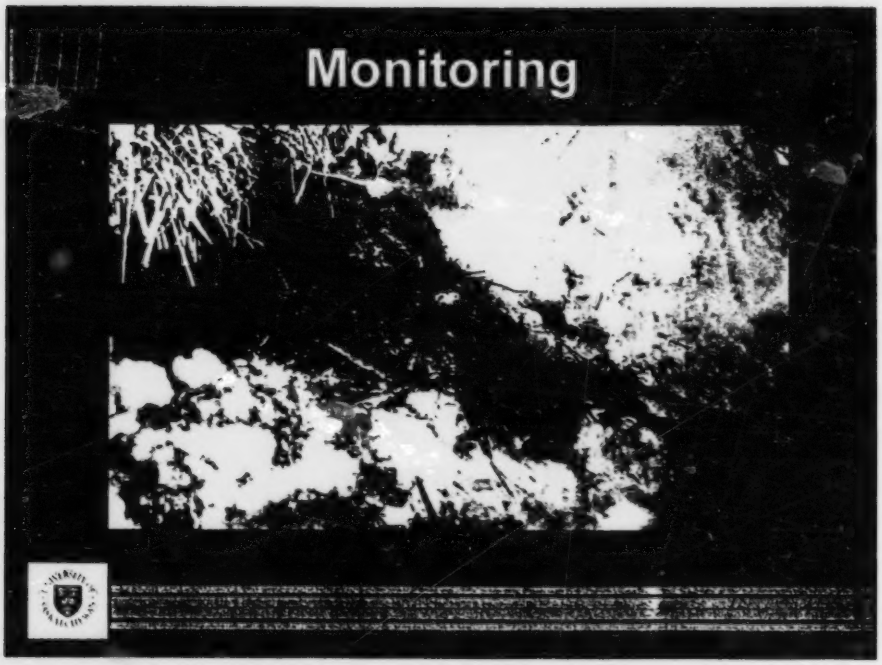
Monitoring

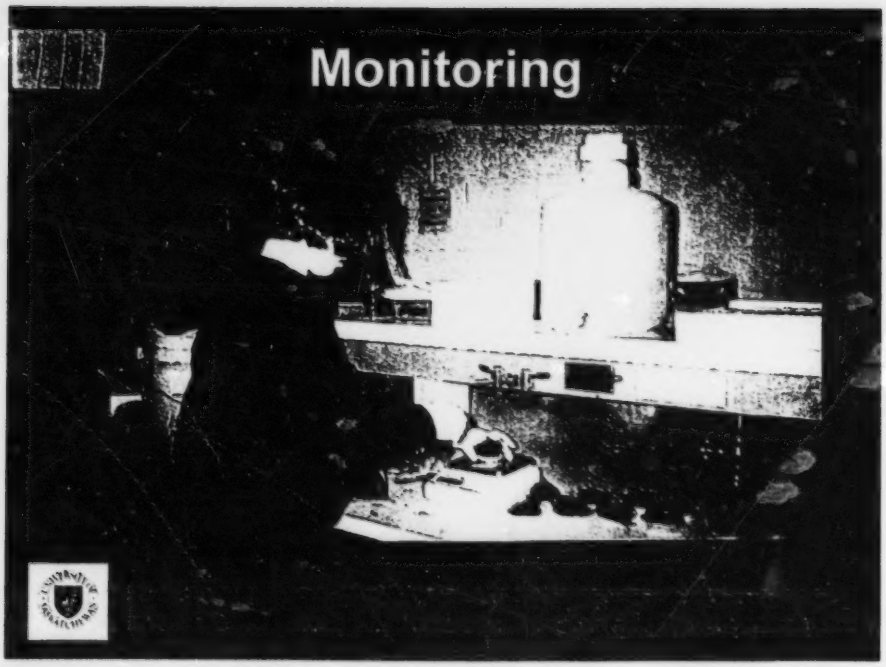
Monitoring - Deads I



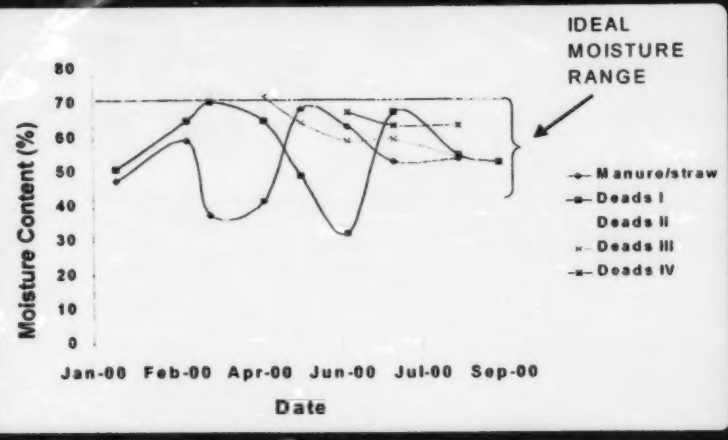
Monitoring - Manure/Straw



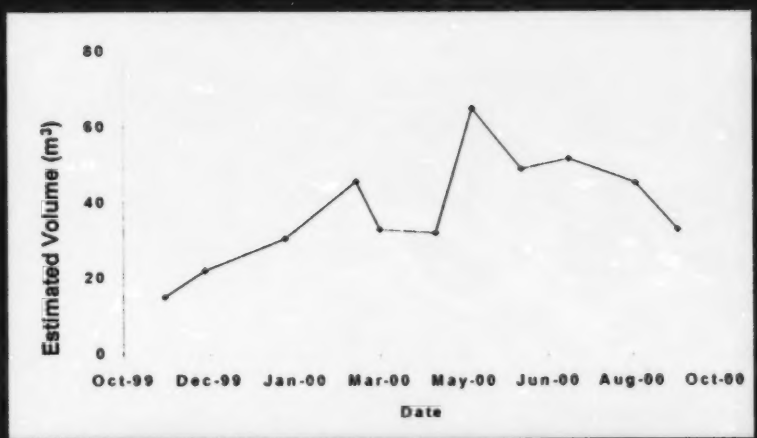

Monitoring

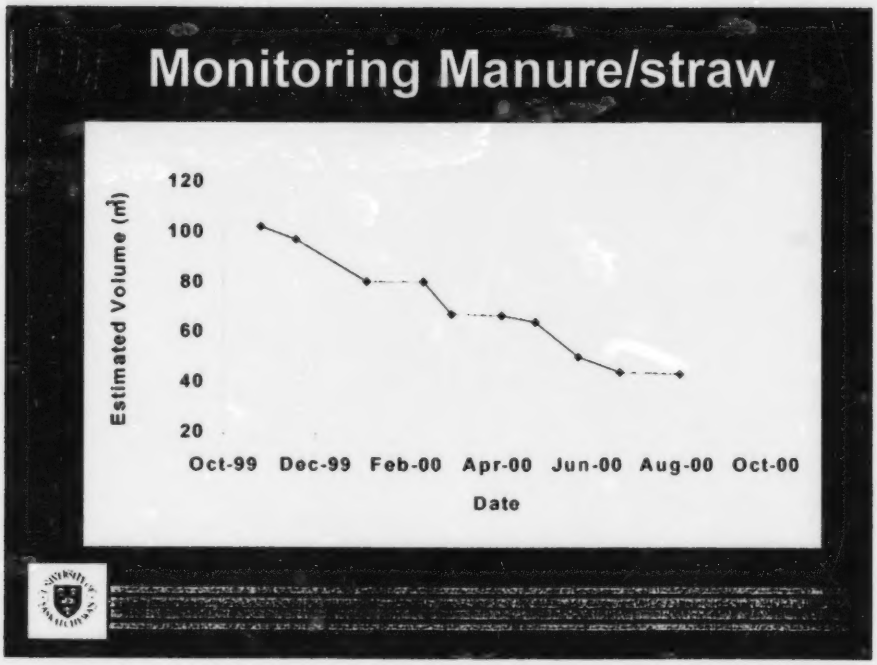

Monitoring

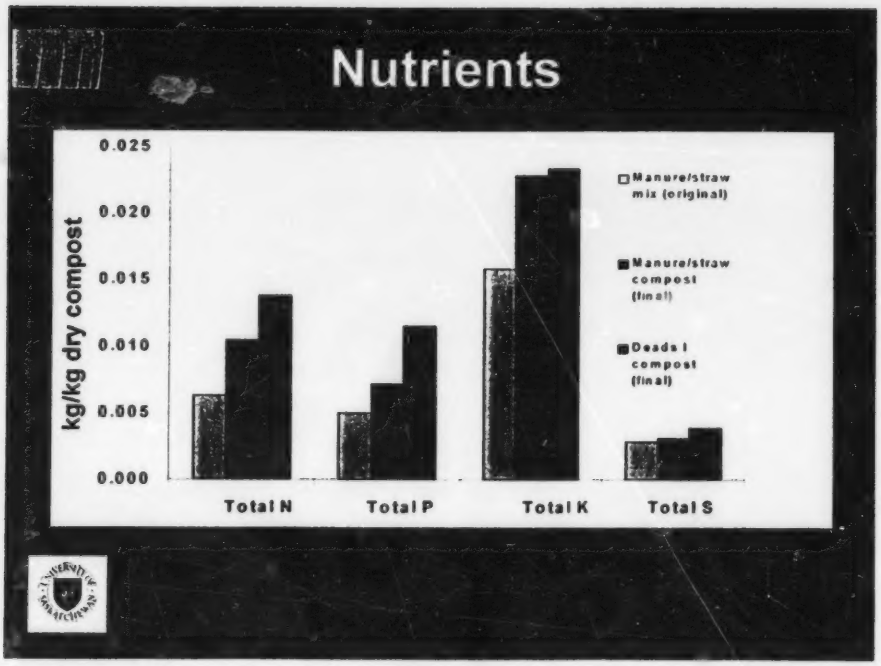
Monitoring



Volume monitoring Deads I

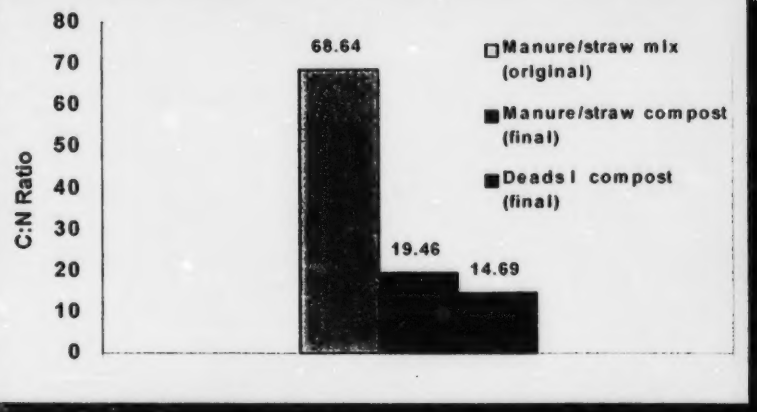






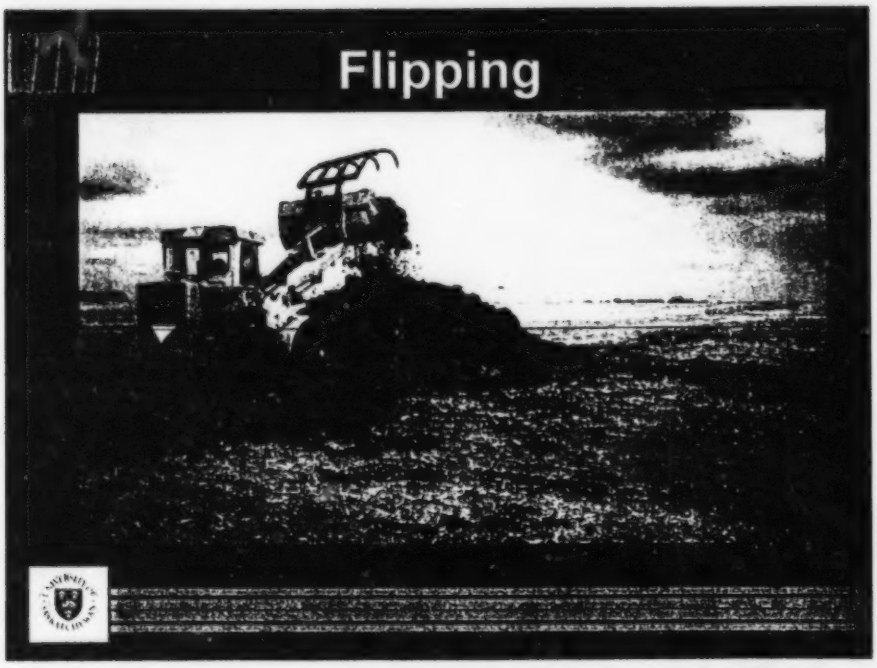
Fonstad et al. 2001

Nutrients



Flipping

Fonstad et al. 2001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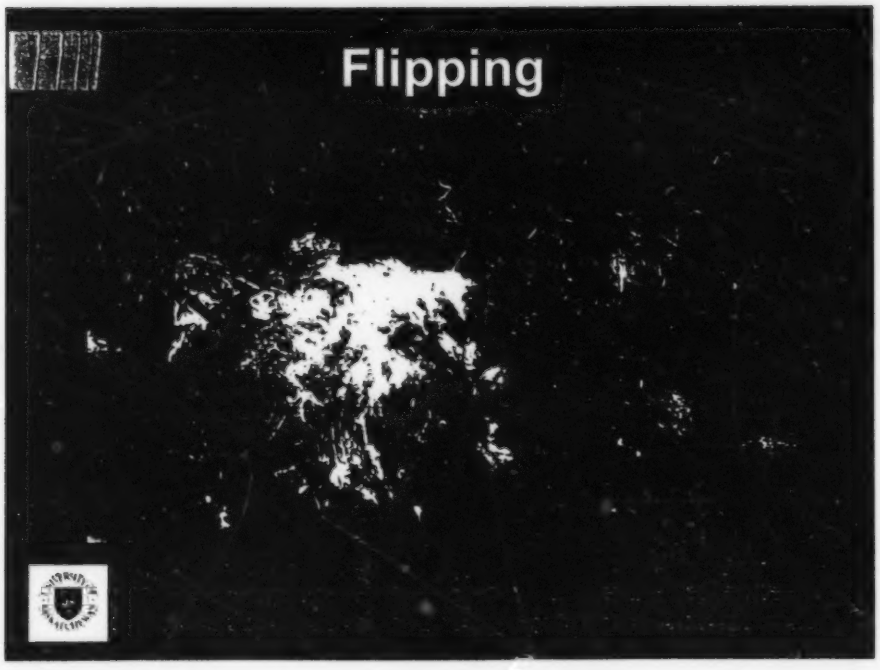
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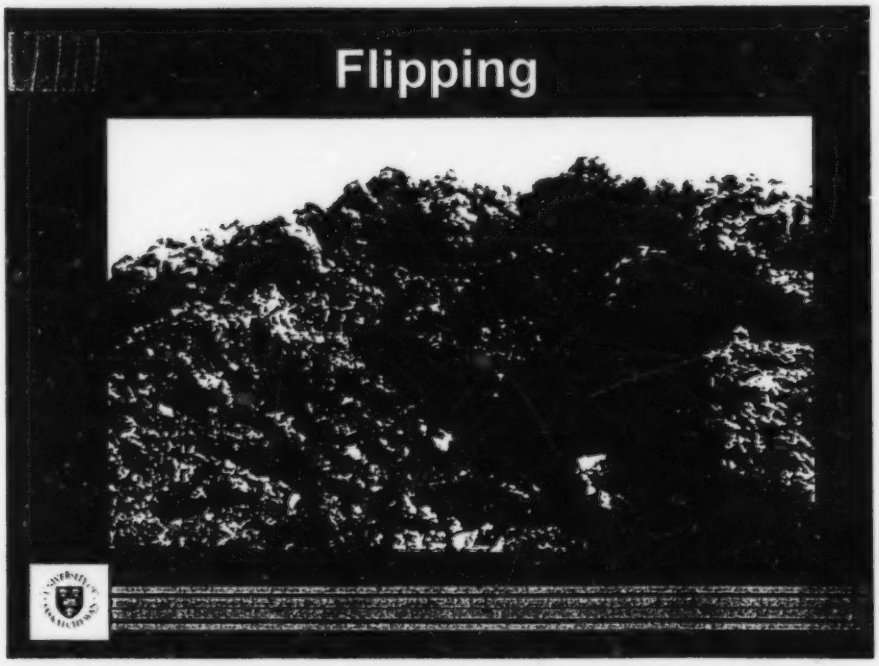
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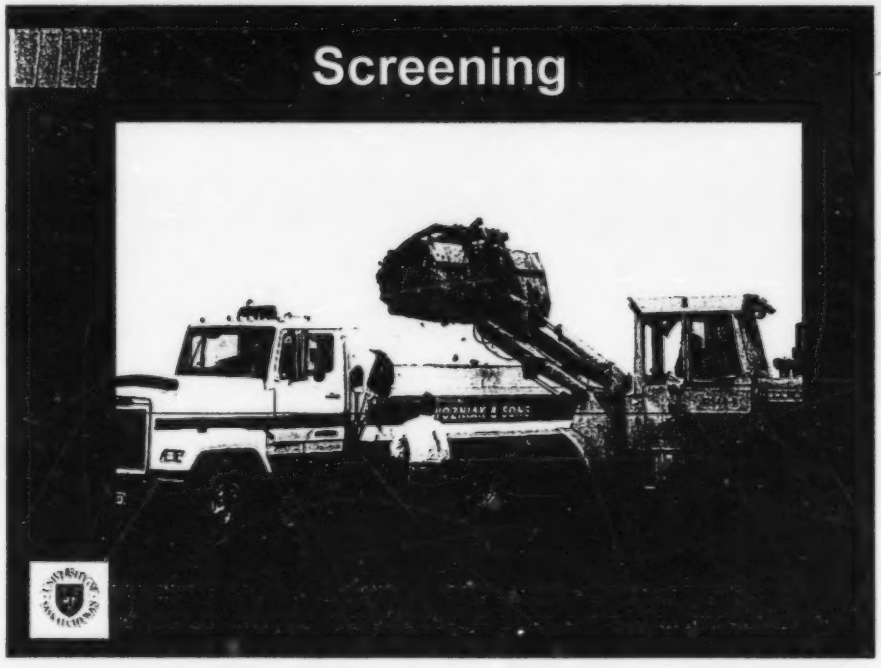
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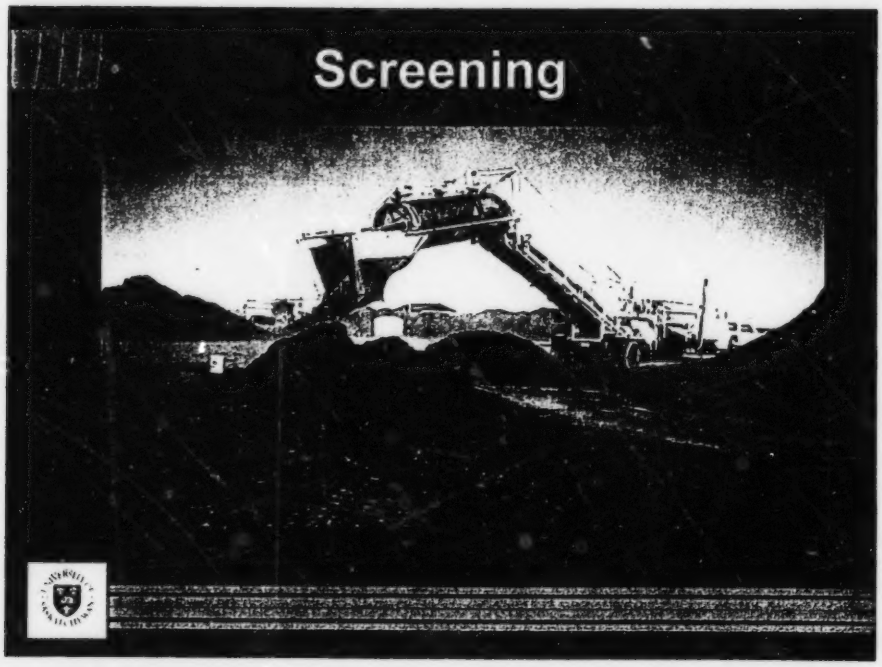
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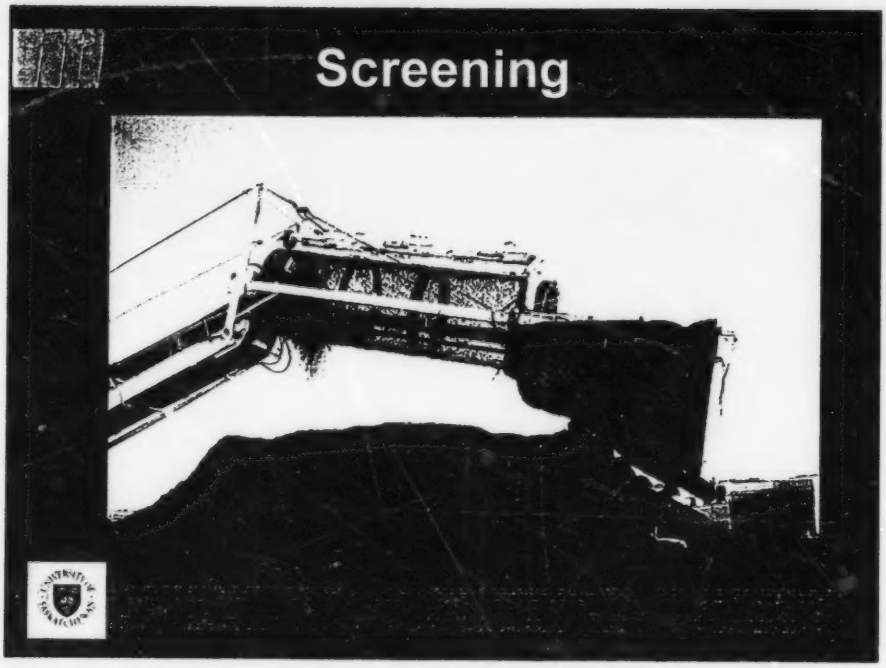
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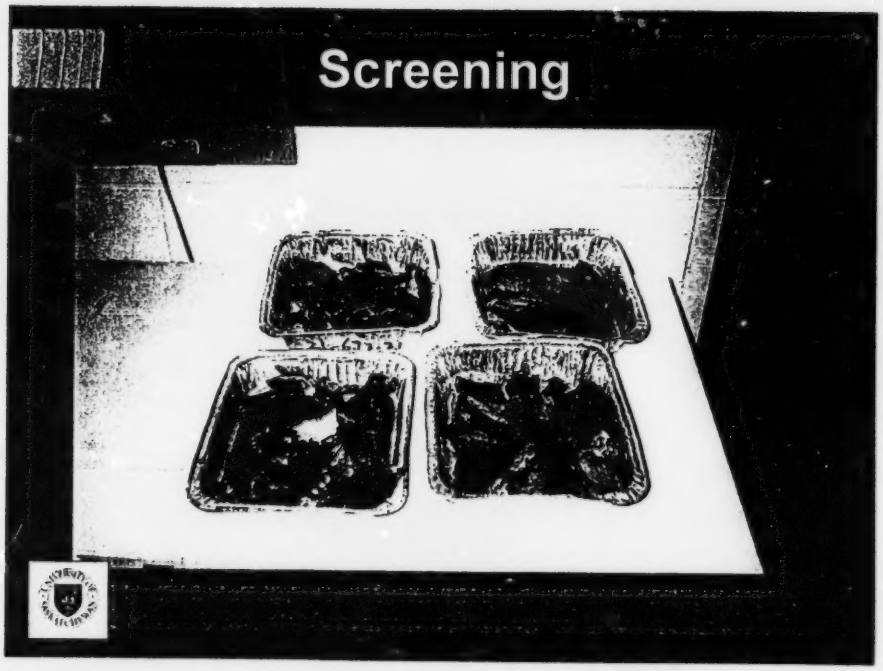
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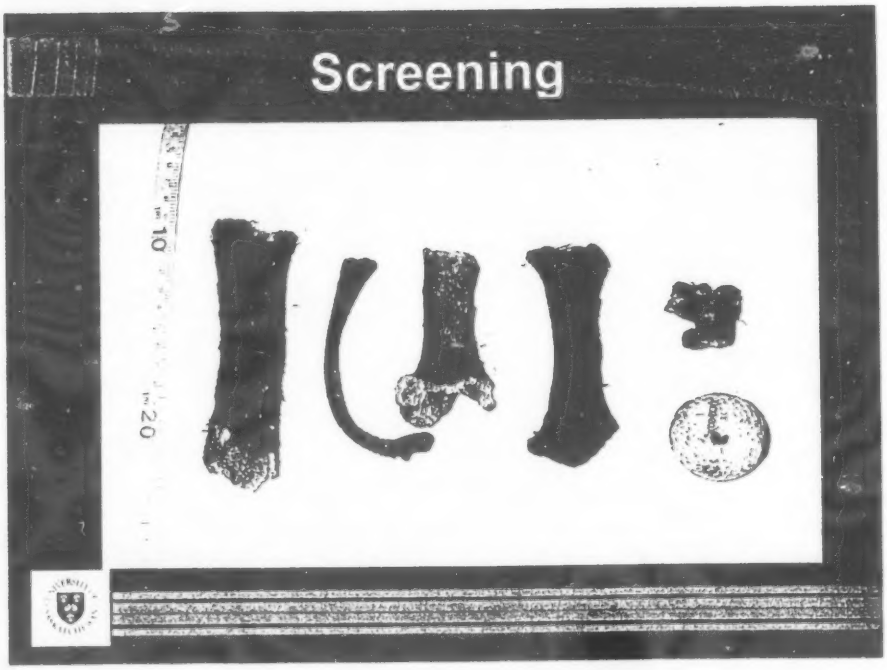
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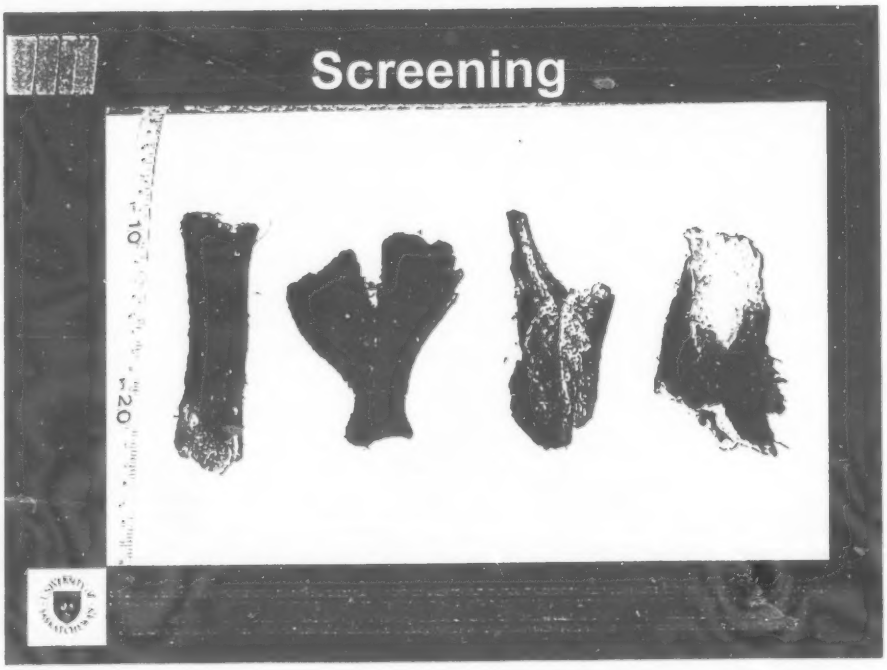
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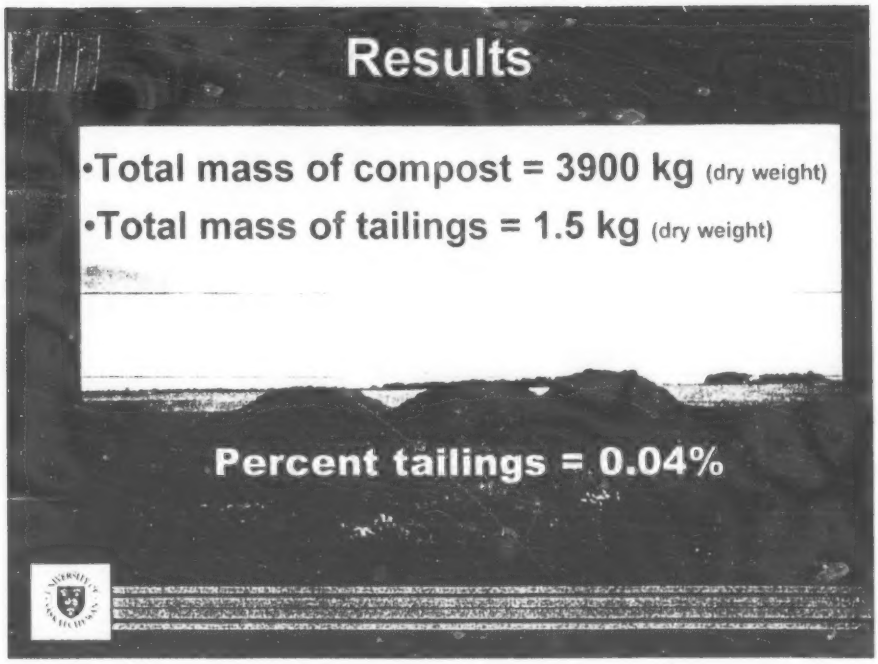
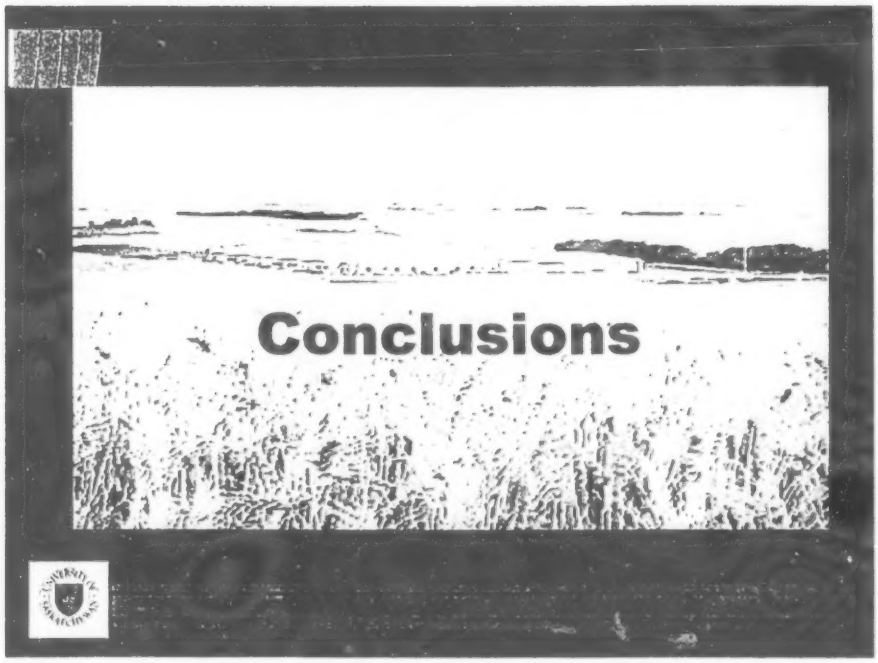

Results
•Total mass of compost = 3900 kg (dry weight)
•Total mass of tailings = 1.5 kg (dry weight)
Percent tailings = 0.04%


Conclusions